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XLI

THE OIL INDUSTRY AND THE COMPETITIVE SYSTEM

A STUDY IN WASTE

THE OIL INDUSTRY AND THE COMPETITIVE SYSTEM

A Study in Waste

BY

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TO

MY MOTHER

SARAH WARD STOCKING

PREFACE

THIS series of books owes its existence to the generosity of Messrs. Hart, Schaffner & Marx, of Chicago, who have shown a special interest in trying to draw the attention of American youth to the study of economic and commercial subjects. For this purpose they have delegated to the undersigned committee the task of selecting or approving of topics, making announcements, and awarding prizes annually for those who wish to compete.

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The present volume, submitted in Class A, was awarded First Prize.

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AUTHOR'S PREFACE

THIS study was begun in the fall of 1919. Since that date the petroleum industry has been developing with great rapidity. An attempt to picture conditions in the industry since the dissolution of the Standard Oil Company of New Jersey in 1911 has been rendered difficult because of this fact. The situation has been a rapidly changing one. But while the picture has been a moving one, the segregated Standard units in a collective capacity have played the leading rôle therein. Their dominating power and influence have furnished the color and tone. There are numerous indications, however, that the Standard Oil group is crumbling from within and that its power as a unit is on the wane. But with account taken of this more recent development, I believe the analysis is in accord with the moving facts.

Likewise, changing conditions within the industry have made somewhat for the elimination of waste at certain points within recent years. The illustrations gathered from the field are of the winter and spring of 1920. Conditions since that date, as revealed by a study of the literature of the industry, apparently have undergone no fundamental changes. And whether or no, the analysis in this regard is in no way invalidated. The main thesis stands true: Competition in the oil industry means waste. To the extent that waste has been eliminated, some form of State regulation, combination, or voluntary coöperation has been instituted. Available evidence indicates no great advance in this direction, however.

The study was begun at the suggestion of my former teacher, Professor Max S. Handman, of the University of Texas, to whom I gratefully acknowledge my indebtedness. The inspiration of my association with him and with Dr.

A. B. Wolfe as an undergraduate at the University of Texas has furnished the impetus to carry on in the field of economic research and teaching. While I was a graduate student at Columbia University, the study took more definite shape under the guidance of Professor Henry R. Seager who has kindly given many helpful suggestions. My year's association in economic research with Professor I. Leo Sharfman, of the University of Michigan, has afforded me valuable training in the technique and method of scientific research. For this and for the stimulating influence of his personality, I am grateful. I wish also to express my appreciation to Dr. Joseph E. Pogue who has read critically the entire manuscript; to my sister, Ruth E. Stocking, who has given much valuable assistance; and to my several associates who have read portions of the study. The timely appearance of this volume has been made possible by the generous and unremitting assistance of my wife, Dorothé Reichhard Stocking, to whom more than all others I feel indebted.

GEORGE WARD STOCKING

DARTMOUTH COLLEGE
June 10, 1925

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barren patch of prairie, until any one of the many products of crude petroleum is placed in the hands of the consumer — here, or in some distant isle of the sea — there shall be no waste and no injustice, and that all the hands through which it passes shall reap a just benefit.

This lengthy quotation is reproduced not through mere desire to criticize such commendation and praise of 'that rare order of genius which lies back of directing [American] minds,'[1] but because this sentiment represents an unfortunate, though a common, misapprehension of the facts. The American people thus far have been supplied with an abundance of crude petroleum and its products at not too great a cost in terms of price, and, therefore, they have not felt the need of a thoroughgoing investigation of the technological and economic efficiency of the industry. True, the Standard Oil Company has been repeatedly attacked, investigated, and subsequently 'dissolved,' but not for the sin of inefficiency and wastefulness. Rather because its monopolistic powers were claimed to have been used to 'pervert the action of economic laws.' It had sinned against the righteousness of the competitive system. Its ostensible dissolution was the result of a governmental effort to reestablish a system 'actuated by the vivifying powers of competition,' with all that this may or may not signify of present and future good.

During the century and a half since the advent of machine technology our industrial situation has undergone continuous change. Our institutional scheme of things, our habits of thought, our collective and individual attitudes toward the problems of industry, have remained relatively constant and fixed, have yielded but slowly to the influence of the altered material order of things. We still have considerable faith in 'the obvious and simple system of natural liberty'; and we still hold with Adam Smith that by pursuing his own interest an individual 'frequently promotes

[1] Preface to *The Evolution of the Oil Industry* by Victor Ross (New York City, 1920), p. x.

that of the society more effectually than when he really intends to promote it.' In so far as the oil industry is concerned to-day, the validity of the proposition may well be questioned. The present inquiry is concerned primarily with the validity of this proposition in its application to the oil industry and with the accuracy of the claims set forth in the above quotation. With faith in the competitive system as a mechanism for effectively supplying mankind with utilities and services, we have endeavored to insure, by the application of the Sherman Anti-Trust Act, the unrestricted operation of competitive forces in the petroleum industry. In the present inquiry we shall endeavor to test both the efficacy and the adequacy of this programme of public guidance and control, or more properly lack of control. In testing the efficacy of our federal policy, we shall inquire into the results of the application of the Sherman Anti-Trust Act in an endeavor to determine the extent to which our attempt to establish competitive conditions in the oil industry has been successful; and in testing the adequacy of our programme, we shall be concerned with the question, Is competition in the oil industry a sufficient guarantee of an economical and orderly exploitation of our petroleum resources? To carry out this dual task it will be necessary, on the one hand, in evaluating the efficacy of our policy, to give a brief account of the development of the petroleum industry, to outline the growth, character, and application of our federal policy toward it, and to analyze in some detail developments in the industry since the dissolution decree of 1911; and, on the other hand, in passing judgment upon the adequacy of the policy, to analyze the technological nature of, and current practices pursued in, the production, transportation, refining, and marketing of petroleum, thereby revealing whatever wastes may be involved under present methods of exploitation.

Inasmuch as the Standard Oil Company has been the dominating factor in the oil industry throughout most of its history, this organization must necessarily occupy the

foreground in our treatment of the development of the industry and of the growth and application of our governmental policy toward it. The historical treatment of the period prior to the dissolution of the Standard Oil Company of New Jersey in 1911 is intentionally brief, and has been borrowed largely from more complete and readily available discussions.[1] Developments in the industry since 1911 have been analyzed in a more thorough and comprehensive manner. Much of the illustrative material presented in the later chapters dealing with waste in the production of petroleum is the result of the writer's personal experience and observation during a year spent in the North Central Texas oil fields in the service of the geological department of one of the large companies operating in that section. The duties connected with this position were varied, but in the main consisted in mapping the Ranger, Desdemona, and Stephens County oil fields, and collecting production and drilling data on wells in the areas mapped. The data were later used for determining sub-surface conditions in the field, and found their application in the drilling operations of the company. This experience afforded an opportunity of observing and studying at close range customary oil-field methods and practices. The wastes observed, however, are notorious, and for the most part have been duplicated in every other oil-producing section of the country. Accordingly, when better illustrations of a point in question have been available they have been borrowed without hesitation, and frequent use has been made of published material from scientific and oil news journals and technical government publications. The writer wishes to make clear in this regard that Texas has not been less concerned than have other States regarding the conservation of petroleum resources. On the contrary, Texas stands in the forefront with Cal-

[1] For more complete accounts see Tarbell, Ida M., *The History of the Standard Oil Company*, 2 vols. (New York, 1904); Montague, G. H., *The Rise and Progress of the Standard Oil Company* (New York, 1903); Bureau of Corporations, *Report of the Commissioner of Corporations on the Petroleum Industry*, 2 vols. (Washington, 1907).

ifornia and Oklahoma among those States which have made a serious attempt to solve the problem of waste.

In view of the waning nature of our petroleum assets and the growing belief that the United States is soon to enter upon a permanent period of declining production, the wasteful methods which have characterized our exploitation of the resource assume greater importance and accordingly they have been treated in considerable detail.

In order that the argument may be intelligently followed by one unfamiliar with the geological occurrence and distribution of petroleum and the mechanics of its exploitation, it has been thought advisable to go somewhat into detail in regard to theories and facts belonging more properly in the field of the natural, rather than the political and social sciences. In making explanations touching such matters the intention has been to present the views most commonly accepted by the technicians of the industry, as gathered from their literature. Obviously, a complete inquiry into the subject is outside the scope of this treatise, and only that material which has seemed fundamental has been presented.

CHAPTER II

HISTORICAL DEVELOPMENT OF THE OIL INDUSTRY

CRUDE petroleum is an oily liquid, composed principally of carbon and hydrogen, with an admixture of some sulphur, a little oxygen and certain nitrogenous substances. It is characterized as having either a paraffin or an asphalt base, depending upon which of these two substances is left after evaporation of the lighter constituents.

The existence of crude petroleum was known to the ancients, its compounds having played an important part in their building operations. Modern excavations in Assyria and Babylonia have revealed fragments of bricks with an asphalt cement clinging to them. Water-tight cisterns with a similar material used as a coating for their walls have also been discovered. The pitch said to have been used to cement the seams of Noah's Ark and the same substance used in building the Tower of Babel is believed to have been a mineral product associated with petroleum. The petroleum-saturated soil on the Russian shore of the Caspian Sea, which, even yet, bursts into flames on the application of a lighted match, is supposed to have furnished the source of the sacred, 'everlasting' fires to which the Parsees made their pilgrimages from India and for the worship of which they built the Temple of Surakhany. Petroleum figured in the pharmacopœia of the ancient Chinese, who considered it valuable because of its curative qualities. It is said to have been turned to the same account by the Indians of North America before the coming of the white man. Later, as the American settlers pushed forward over the Alleghenies, they encountered it in their search for salt, in proximity to salt brine secured from drilled wells. At this period, however, petroleum was regarded as a nuisance since its value as an illuminant had not yet been recognized.

By the middle of the nineteenth century, kerosene, or more properly 'coal oil,' had been refined in this country for illuminating purposes by the distillation of cannel coal. During the succeeding decades its use had become more widespread, especially in the Eastern cities. In 1854 Jonathan Eveleth and George H. Bissell, New York lawyers, conceived the idea of securing a cheaper illuminating oil from crude petroleum. Accordingly, they journeyed to Western Pennsylvania where oil seeps were known to occur. Near Oil Creek they secured a sample of petroleum which they submitted with the request for an analysis to Professor Benjamin Silliman of Yale University, one of the most noted chemists of his day. Professor Silliman stated in his report that he found in the sample the source of a good illuminant and a good lubricant. Encouraged by this report, Bissell and Eveleth organized the Pennsylvania Rock-Oil Company for the purpose of oil production. The efforts of the Company met with little success, however, and after 1858 nothing more was heard of the organization.

In 1859, James M. Townsend, a New York lawyer who had been one of the original stockholders in the Pennsylvania Rock-Oil Company, secured the services of E. L. Drake (a man with apparently no special qualifications for the task, having formerly been a conductor on the New York and New Haven Railroad) to make another attempt in the Oil Creek region to obtain petroleum in commercial quantities. Drake's efforts finally proved successful, and small quantities of petroleum were secured from oil springs and sold on the market for approximately twenty dollars per barrel. With an idea of increasing the production, it was decided to drill a well and, if possible, find the source of the oil. Work was begun in the early part of 1859, and in August of the same year, at a depth of sixty-nine feet, the hole filled half full of fluid. A small pump was installed and the well yielded about one thousand gallons of oil daily.

Invention being the mother of necessity, the discovery of petroleum in commercial quantities resulted in its be-

coming within a few years the main dependence of civilized communities for illumination. With the growth and development of modern industrial machinery the uses of oil have multiplied until to-day it is practically indispensable both as a lubricant and as a motive power. Literally, the wheels of industry could not turn without it. In 1860 its sole use was as a source of refined kerosene, which served for purposes of illumination as a superior substitute for whale oil, tallow candles, and 'coal oil.' To-day its products are numbered by the hundreds and enter into every phase of our industrial life. Its supremacy as an illuminant stands uncontested in the remoter corners of civilization where electricity has not yet made its appearance. It is the sole source of gasoline, which, with the development of the internal combustion engine, has become a necessity in the daily life of civilized communities. It furnishes the chief source of lubricants for our industrial mechanism, for which, quantitatively at any rate, there are no satisfactory substitutes. Petroleum, indeed, has so woven itself into the fabric of our modern economic structure that there seems to be no doing without it. So dependent have we become upon petroleum and its products that, while in 1920 the United States crude production was more than forty times that of any year prior to 1875 and more than twice that of 1911, it was insufficient by almost 100,000,000 barrels (approximately one fourth of the total production) to meet our own current needs.

This remarkable development of the petroleum industry has been closely associated with the transformation of industry at large, upon which it has also been dependent. The progress of science and invention has paved the way for new uses of petroleum. But the influence has been reciprocal. Increased petroleum production has led to new uses of its products. Thus, increased supply has meant an increased demand; and increased demand has called forth an increased supply.

As previously stated, in 1860, the sole demand upon the

industry was for kerosene as an illuminant. The process of distillation was a simple one since the crude still which had formerly been used in the distillation of 'coal oil' was readily adapted to the new industry. The process yielded benzine, gasoline, kerosene, paraffin, and a residuum of tar. The demand for gasoline was at first slight, and there was constant temptation to mix it with commercial kerosene despite the increased danger of explosion which resulted. The commercial traffic in 'coal oil' had already attained considerable development. The very year in which Drake discovered oil, Merril and Donner, refining chemists of Boston, distilled 7500 tons of coal, by which operation they are said to have cleared approximately $100,000. The Drake discovery accordingly found a developed market for its output. The Drake well was completed in August, 1859. During the remaining months of that year it produced about two thousand barrels of oil, which sold on the market at twenty dollars per barrel. The opportunities for enormous profits were quickly seized by a speculative public, and an oil boom partaking of the nature of the gold boom of '49 resulted. The consequence was a phenomenal increase in production. The problems of storage and transportation became serious. There were not enough barrels in America to handle the constantly increasing output. Reservoirs dug in the earth, lined with cement, logs, or planks, were resorted to; but the loss from evaporation, capillary attraction and fire soon caused this method to be abandoned. Necessity led to the substitution of large wooden tanks, which in turn quickly gave way to the more economical and durable iron or steel tanks used to-day.

The transportation problem was equally serious. Soon after oil was discovered, Oil Creek, joining with the Allegheny River at Oil City, became an important highway for flatboats with their barreled oil cargoes. At one time as many as one thousand boats, thirty steamers, and at least four thousand men were employed in this traffic. Three railways, the Philadelphia and Erie, the Buffalo and Erie,

and the Atlantic and Great Western, were within teaming distance; and teamsters equipped for service appeared in profusion. By 1865 railway connections had been extended to the oil fields. The problem of transporting the oil from the wells to the tracks still remained. For a time teaming continued to be the method used. Not long after the Drake well was completed, the feasibility of transporting the oil through pipes by the aid of gravity and pumps was discussed. By 1862 a company had been incorporated for this purpose. Although this company seems to have done nothing more than get a charter, by 1863 at least three short pipe lines had been put in operation. These first lines did not prove successful. By 1864, however, the efforts in pipe-line construction of a Mr. Van Syckel were successful and by 1866 pipe-line transportation of oil from the wells to the railways had superseded the work of teamsters.

With such rapid developments refineries sprang up as mushrooms overnight. Due to the great difficulty of transporting materials to the oil regions the bulk of the crude oil was transported at the outset to the large manufacturing cities for refining. Erie, Pittsburgh, and Cleveland became inland refining centers of first importance, seconded by Boston, New York, Philadelphia, and Baltimore in the seaboard region. By 1865, however, at least twenty refineries had been established in the oil regions between Titusville and Oil City, and by 1872 the daily refining capacity of this area had increased to ten thousand barrels. It is estimated that at that time the oil industry was using a capital of $100,000,000. Within the following seven years, the investment is said to have doubled.

In 1860, the production of crude petroleum totaled 500,000 barrels. In 1861, production increased to more than two million barrels. Such a flood of production upon a relatively virgin market led to a complete demoralization of prices. In December, 1861, oil at the well brought only ten cents per barrel, the average price for the year being forty-nine cents as compared with an initial price in 1859

of twenty dollars. This demoralization did not last long, however. The supply of a cheap and superior illuminant brought with it an increased demand, and, while production increased some 44 per cent during 1862, the average price for the year advanced more than 100 per cent to $1.05 a barrel. A decrease in production during 1863 and 1864 led to a further rise in price until in July, 1864, oil sold for $14 per barrel, the average for the year being $8.06, a price that has never since been attained. From 1866 to 1872 production increased about 100 per cent, the price fluctuating in the meantime from $1.35 per barrel in December, 1866, to $7 per barrel in January, 1869.

Such a wide variation in the price of crude petroleum is to be explained largely by the highly competitive nature of oil production coupled with the physical characteristics of the recovery process. Oil wells show initially a high flush production with a rapid decline. Such a situation leads to irregularity in the annual supply, a flood of petroleum on the market in flush-production periods being followed, in the absence of new developments, by a rapid decline. Such fluctuating price behavior has serious disadvantages. It means the probability of enormous losses, offset, it may be, by enormous gains; and in the absence of contravening circumstances it generally results in combination and monopoly. Let us see what has happened in the oil industry.

Of the many cities first selected for the manufacture of petroleum products, Cleveland seemed destined by geographic location to take the lead. Although two hundred miles from the oil region, Cleveland commanded by rail and water the entire Western market. It was also closely linked with the East by rail and by water through Lake Erie and the Canal. Thus favorably situated, by 1869, Cleveland stood foremost as an oil-refining center, having some twenty-six refineries of varying capacities.

In the midst of the confusion which characterized the oil industry during its early history, there was launched a refinery enterprise which was destined to acquire a position

of dominance in the petroleum world. Reference is made to the early venture under the financial leadership of Rockefeller and Clark, produce commission merchants of Cleveland. In 1862 this firm backed Samuel Andrews, said to have been a mechanical genius, in the establishment of a small petroleum refinery. The business grew and prospered. By 1865 Rockefeller and Clark had invested $100,000 in it. With an eye to the main chance, Rockefeller sold his interest in the commission business in 1865 and thereafter devoted his entire energies to oil. To this end he formed a partnership with Andrews. The oil industry grew rapidly. The firm of Rockefeller and Andrews enlarged their output more rapidly. Soon with H. M. Flagler they opened a house in New York City for the marketing of their products. A second refinery was started in Cleveland under the firm name of William Rockefeller and Company. Finally, in 1870, these various concerns were united into the Standard Oil Company of Ohio, which was incorporated under the laws of the State with a capitalization of one million dollars.

At this time the Standard controlled but a small percentage (about 10 per cent) of the total refining business of the country. It was, however, the most important single refinery enterprise. Its capacity was about fifteen hundred barrels daily, while the total capacity of the approximately 250 refineries in the country was in the neighborhood of fifteen thousand barrels. Many of these refineries were small in capacity and ill-fitted to refine oil on an economical basis. A considerable number were located in the oil regions remote from marketing centers.

Assuming equality in transportation facilities, the refinery, under a system of competition, occupies a key position in its influence on prices. Refineries must compete with each other in the purchase of crude oil and they likewise compete in the disposition of their products. In 1872, two years after the organization of the Standard, the daily refinery capacity of the country is said to have been between 45,000 and 50,000 barrels. The total oil production

for that year in round figures was 6,293,000 barrels, a daily average of about 17,000 barrels. Thus the total refinery capacity was nearly three times as great as the amount of oil to be refined. Competition among refineries for an insufficient crude supply, as judged by refining capacity, tended to keep up the price of crude.

The average price of crude from 1866 to 1872, while it had undergone temporary fluctuations, had shown no tendency to decline despite an increase in production of approximately 73 per cent. During the same period, the export price of Standard white kerosene at New York City had shown a marked tendency downward, the price having fallen from $30.08 in 1866 to $20.97 in 1872.[1] This anomalous price behavior is to be accounted for in part by reductions in the cost of refining and transportation incidental to the normal development of the petroleum industry, and in part by the excessive competition among refineries in the purchase of crude oil and in the disposal of their products. Such a situation in the long run would mean the disappearance of the more inefficient producers, according to the laws of competitive price. Immediately, it meant fluctuating loss and profit depending on the demand-and-supply situation at the given time.

Both credit and blame have been enthusiastically extended Mr. Rockefeller for the early part he played in the elimination of competition in the refining, transportation, and marketing of petroleum. Both seem beside the point. An economic situation had arisen wherein competition threatened loss, and centralized control meant economies and increased profit. Such a situation awaits only the appearance of shrewd business acumen and judgment until monopoly will develop. Mr. Rockefeller afforded these qualities in high degree. In the early seventies, he realized the disastrous effects likely to follow continued competition.

[1] Bureau of Corporations, *op. cit.*, part II, pp. 49 and 84. Data regarding the domestic prices of finished petroleum products during this period are not available.

Despite the fluctuating conditions of the petroleum market he had conducted his own business in a financially successful manner. Under the guidance of his shrewd business foresight and indomitable perseverance, the Standard Oil was destined to rapid expansion. The first attempt at monopoly, however, was initiated from the outside, late in the fall of 1871. At this time a group of Philadelphia refiners conceived the plan of secretly organizing and incorporating a group of the leading petroleum refiners of the country, in order that a more favorable freight rate than was enjoyed by competitors might be secured by reason of the large-scale traffic handled. The result was the organization of the South Improvement Company, controlled by a group of Philadelphia and Pittsburgh refiners and the Rockefeller interests. In the meantime secret arrangements had been consummated with a number of the leading railways of the country, whereby the open freight rate on oil shipments was to be considerably increased, and the South Improvement Company was to be allowed a substantial rebate on oil shipped not only by itself but by its competitors. For example, the open rate on crude oil from the oil regions to New York was to have been made $2.56 per barrel. On this amount the South Improvement Company was to have been allowed a rebate of $1.06 per barrel on all its own shipments, as well as a rebate of the same amount on all petroleum shipped by its competitors.[1]

Such an arrangement, had it been carried out, would have meant the disappearance of the concerns not included within the South Improvement group. A premature announcement of the plans of the organization before they had been put into operation led to an outbreak of fierce opposition in the oil region and a demand for a Congressional inquiry. In the face of this outburst the railroads concerned repudiated their contracts. Prior to this turn of events, however, and while the plans were still kept secret, the Standard Oil Company had used the power which these arrangements

[1] Bureau of Corporations, *op. cit.*, part 1, p. 56.

offered it, to effect, either voluntarily or by coercion, the purchase of twenty-one of the twenty-six independent refineries of Cleveland, thereby increasing its refinery capacity from fifteen hundred to ten thousand barrels daily. Within a few weeks after the disclosure of the South Improvement Company's plans and the abrogation of the contracts by the railways concerned, the Standard Oil Company had secured on its own account secret freight discriminations which gave it an added advantage in its unavowed monopolistic intentions.

Thus, while the South Improvement scheme was never realized, the Standard Oil Company emerged from the situation in a position of greater strength for a still further extension of its control. In 1872 its capital was increased to $2,500,000. In 1874 the three most important rival refineries were brought into the group — Warden, Frew and Company of Philadelphia; Charles Lockhart of Pittsburgh; and Charles Pratt and Company of New York.

The history of the decade of the seventies was marked by the temporary formation and subsequent dissolution of associations and combinations of refineries, in all of which the Standard was a leading spirit. In 1872 the Petroleum Refiners' Association was organized, under the presidency of Rockefeller, with control of four fifths of the refining interests of the country. This organization was short-lived, but soon after its dissolution the Central Association of Refiners was organized in 1874. Under Rockefeller's leadership the Standard Oil Company of Ohio was given authority to make all purchases of crude oil and to make allotments to the member refineries. The Standard Oil was also to have control over sales of the refined products, and was to negotiate all freight and pipe-line expenses.

In 1875, the Standard Oil Company of Ohio increased its capital stock to $3,000,000. During the following four years the Standard secured control over most of the leading independent refineries of the country by effecting a secret exchange of its stock for stock in the independent com-

panies. In this manner it secured control over refineries located in Brooklyn, Philadelphia, Baltimore, and Parkersburg. Meanwhile, it had absorbed practically all the independent refineries in the Oil Creek region. So rapidly had the process of absorption and combination been progressing that from 1870 to 1879 the Standard control of refined petroleum products had increased from approximately 10 per cent to the monopolistic figure of 90 per cent.[1]

By 1866 pipe lines had completely superseded the work of teamsters in the local transportation of petroleum from the wells to railway shipping points. Simultaneously with the development of combination in the petroleum industry there progressed the process of integration. The oil industry seems especially adapted to this process. Without attempting at this point a complete discussion of its advantages, suffice it to say that a steady and certain supply of oil cannot be assured in the absence of adequate transportation facilities. From an early stage in the development of the petroleum industry refineries have recognized the advantages of control over their own pipe lines, and since 1870 it has been a common practice for a refinery to pipe oil directly from the field to its stills by its own lines. It is not surprising, therefore, to find the Standard, in the forefront of refinery enterprises, early extending its control to the pipe-line service.

The Standard's initial entrance into the pipe-line business occurred in 1873. In this year J. A. Bostwick and Company constructed a pipe line in Clarion County, Pennsylvania. Subsequently it became a Standard subsidiary and the firm name was changed to the American Transfer Company. With this modest beginning the Standard pursued a policy of rapid expansion through acquisition and construction. In 1874 it acquired one third of the stock of the United Pipe Line Company. This Company was thereupon reorganized as a Standard subsidiary with control of approximately 30 per cent of the pipe-line facilities of the oil fields.

[1] Bureau of Corporations, *op. cit.*, part 1, pp. 48 *et seq.*

In the same year the extension of the Standard control was facilitated through the organization of a pipe-line pool under the leadership of the reorganized United Pipe Line Company and the Empire Transportation Company. Although the pool lasted only a short time, so consistent was the Standard's policy of acquisition, extension, and absorption that by 1879 the Standard's control extended over 80 per cent of the local pipe-line transportation service.

Thus by 1879 the Standard's ascendancy in at least two branches of the industry had been established. With control over pipe lines secured, the Standard attempted to harmonize the competitive situation among railways by allocating to each a share in the transportation of petroleum. This attempt was somewhat rudely interrupted in June of that year by the completion under independent auspices of the first trans-mountain pipe line from the oil region to the seaboard. This idea had been advanced at a somewhat earlier date, but had received little encouragement at the hands of the Standard. With transportation controlled largely by the Standard, the position of the remaining independent oil refineries was by this time precarious. Their continued existence depended upon a ready supply of petroleum. To solve this problem the Tide Water Pipe Line Company had begun the construction of a pipe line from the oil regions over the mountains to the seaboard as a feeder to a number of independent refineries in the neighborhood of New York City. The attempt was rewarded by success in June, 1879.

The Standard met this threatened new competition promptly and decisively. Railroad rates were heavily reduced, and the United Pipe Line Company cut their local pipeage charge. Also the Standard very soon acquired the control of the independent refineries for which the Tide Water concern was a feeder, began the construction of an inter-mountain line of its own, and eventually effected a compromise with the Tide Water concern through purchase of a minority interest in the Company's stocks.

Control over the refining and transportation of petroleum having thus been secured by the Standard interests, there remained yet to be accomplished the consolidation and concentration of this control in the hands of a centralized group functioning as a unit. This was accomplished in 1879 by the formation of the first Standard Oil Trust. By its various acquisitions the Standard Oil Company of Ohio had increased its list of stockholders from three or four at the time of its organization to thirty-seven by April 8, 1879. On this date a trust agreement was entered into between the thirty-seven stockholders, whereby they turned over the stock which they owned in more than thirty separate companies to a board of three trustees. The trustees agreed to manage the stock in the interests of those stockholders. This trust agreement was in operation for about three years. During this period additional companies were acquired by purchase of their stocks out of the profits of the Trust. On January 1, 1882, the old trust agreement was revoked and a new trust was organized known as the Standard Oil Trust of 1882. According to this new agreement the former holders of stock in the Standard and allied companies exchanged their stock in said companies for trust certificates, issued by a board of trustees consisting of nine members, and having a face value equal to the appraised value of the properties acquired. Control of the stock so exchanged became vested in this board, power thereby being centralized in its hands. This new Trust comprised the entire capital stock of fourteen oil companies, a major portion of the stock in twenty-six other companies, and the interests of some forty-six individuals. It is important to note that by the terms of this agreement the trustees did not acquire absolute ownership of the stocks, but they merely retained the stocks on behalf of the holders of trust certificates; and more important still, the stocks were held for the joint account of holders of trust certificates, rather than for the individual account. In other words, the holders of trust certificates lost their title to particular stocks and acquired

instead a proportional interest in all the stocks or property. This was the fundamental feature of the agreement and of very great importance in the light of subsequent dissolution proceedings.

Control over the transportation and refining of petroleum carries with it control over the marketing process. Nevertheless, the Standard did not wait until control over these antecedent operations had been secured before attempting to acquire control over the marketing situation. Rather, efforts were directed simultaneously in the two directions, the one serving as an aid to the other. Control over the three fields having been established, the Standard interests set themselves to organize marketing operations in an intelligent and systematic fashion. Independent refineries had had their own agents out looking for markets; others sold to wholesale dealers and jobbers, who in turn resold to local dealers, generally grocers. To replace these independents with their own employees was the Standard's task. The task was attacked in a systematic and organized fashion. The United States as a marketing area was divided into a number of large divisions, each under the supervision and control of a Standard marketing subsidiary. For example, the Waters-Pierce Oil Company of St. Louis, Missouri, had charge of a certain portion of the Southwest; Chess Carley and Company, of Louisville, Kentucky, had charge of certain States in the South, including Tennessee, Kentucky, and Mississippi. And so it ran. Each of these larger divisions was subdivided into sections supervised by local agents. This system, inaugurated prior to the trust agreement, had attained a working perfection within a decade and has remained in force with little change until the present time.

To establish and maintain this marketing control, detailed information in regard to oil movements of competitors was very useful. The original plans of the South Improvement Company had aimed at supplying this information. This scheme had bound the railways to send

daily to the principal office of the Company detailed reports on all oil shipped, the name of the shipper, the quantity and kind of oil, the name of the consignee, the destination and cost of the freight. True, the surreptitious plans of the South Improvement Company were abandoned. Nevertheless, the Standard at an early date, through the establishment of a spy system which was operated in conjunction with local freight agents, oil salesmen, and local dealers, secured at one time or another virtually all the information in regard to oil movements of competitors that the South Improvement Company originally hoped to provide.[1] Such information enabled the Standard to wage an intelligent and well-planned war against independent concerns wherever and whenever it was deemed desirable — always from the viewpoint of maintaining a monopoly control of the oil industry.

Thus, while the Standard Oil Company secured practically a monopoly in the transportation, refining, and marketing of petroleum, it has never enjoyed a monopoly of oil production. Despite the more recent contributions of geology, the location of an oil well is an uncertain and hazardous enterprise. Only by the drill can the presence of oil in commercial quantities be definitely determined. Speculation and gambling with the hope of large returns have been responsible, through 'wildcatting' operations, for the discovery of the greater portion of oil-producing areas. The physical characteristics of oil production thus make monopoly difficult. Nor is it altogether desirable, since in its absence the speculative hazards can be largely shifted to the venturesome 'wildcatter.' Nor is it necessary for a monopolistic control of the industry, since control over refining and pipe lines and the consequent elimination of competition in purchasing the crude product mean, in effect, monopoly over the industry at large.

Although the Standard has never produced the bulk of the raw product, it has in more recent years loomed large in

[1] Tarbell, Ida, *op. cit.*, vol. II, pp. 35–41.

production enterprises. The Standard entered this field somewhat later than it entered the other branches. It was not until 1879 that the Forest Oil Company, which was for a long time one of the important producing interests of the Standard, was organized. In the succeeding decade, however, the Standard became the largest single producer of crude oil in the country, a position which it retained until the dissolution decree of 1911.

The Standard Oil Company was organized in 1870. The final organization of the Trust proper as a working unit was consummated in 1882. In the intervening twelve years a monopoly control of the oil industry had been established. At the time of the organization of the Trust the Standard transported roughly 80 per cent of the crude product, refined approximately 90 per cent, dominated the marketing of refined products, and as chief purchaser of crude oil was the controlling factor in fixing the price of the raw product.

During the next decade the policy of expansion was continued by absorption of competitors as they appeared and by the normal growth of the industry. By 1888 some thirteen new companies had been incorporated into the larger body, and in this manner the Standard monopoly power was maintained intact despite the numerous efforts of independents to gain a foothold in the industry.

CHAPTER III

THE SOURCE OF THE STANDARD OIL COMPANY'S POWER

THAT the Standard Oil Company enjoyed a large measure of monopoly control over the oil industry from the late seventies until its dissolution in 1911 is a matter of common knowledge. We have traced very briefly the historical steps by which this control was secured. In the following two chapters we wish to analyze (1) the means by which this control was established, (2) the economic effects of this control in terms of price and profit, and (3) the collective attitude of the American people toward the monopoly power of the Standard as reflected in our governmental policy toward the industry.

Much has been written regarding the unethical practices indulged in by the Standard in building up its financial and economic power. Without attempting an ethical evaluation let us review the several factors which were instrumental in the establishment and maintenance of this power. In brief, the more important influences were: (1) The business ability of the organizers of the Standard Oil Company, (2) the organization of the South Improvement Company, (3) the granting by railroad companies of rates, preferences, and other discriminations in favor of the Standard, (4) 'unfair' marketing practices, (5) restraint by control of pipe lines, (6) ability to locate refineries at strategic points, and (7) the advantage which comes from large-scale operations in the oil industry.

First, as to the business ability of the organizers of the Standard Oil Company. The unusual business ability of the men who guided the destinies of the Standard Oil Company throughout its early history must be taken for granted. The facts speak for themselves. The Standard's financial

and industrial success could only have been attained by men with remarkable business acumen, tremendous energy, and an indomitable determination to succeed. Business success is measured in pecuniary terms. These men attained it. With an eye open always to the main chance, they quickly seized opportunities as they presented themselves — and whenever advantageous, created new opportunities for increasing the scope of their operations. They played a rôle of no little importance in effecting the greatness of the Standard enterprise.

Secondly, as to the organization of the South Improvement Company. Taking the original Standard Oil Company as a point of departure and a rapidly developing industry as an economic fact, the South Improvement Company's agreement with the railroads, although never made operative, served to raise the Standard Oil Company to a position of commanding power. It has already been described how, by the aid of this secret agreement, Rockefeller and his associates were enabled to secure control of twenty-one of the twenty-six independent refineries of Cleveland, and thereby to increase the Standard's daily refining capacity from 1,500 to 10,000 barrels, one fifth of the total refining capacity of the country at that time.

Thirdly, as to the granting of rates, preferences, and other discriminations in favor of the Standard by railroad companies. Although the secret arrangements with the South Improvement Company were repudiated, yet after becoming with its aid the largest single shipper of crude petroleum and its refined products, the Standard Oil Company was enabled to secure almost equally favorable, discriminating rates on its own behalf. The facts indicate that within a few weeks after the repudiation of the South Improvement Company's contracts, the Standard was enjoying rates substantially lower than its competitors. Railway discrimination continued to exist in favor of the Standard from this early period until its investigation by the Bureau of Corporations in the first decade of this

century,[1] and the railway rebate was perhaps the most important single factor in the Standard's successful fight against its competitors. The immense advantage enjoyed by the Standard in this regard is best indicated by concrete figures of preferences granted. For example, at one time when the open rate on crude petroleum from Western Pennsylvania to the seaboard was $1.40 per barrel, the Standard was able to ship its oil for 88½ cents per barrel. At the same time the Standard paid 80 cents freight per barrel on its refined products, while its competitors were required to pay $1.45.[2] In some instances the Standard not only received a better rate than independents, but it received a rebate on all oil shipped by its competitors.

Fourthly, as to 'unfair' marketing practices. The differential advantage obtained as a result of railway discrimination, coupled with its greater financial strength, permitted the Standard to 'cut prices to kill' wherever and whenever desirable, with the resulting impetus toward combination which such practices necessarily afford.[3] Likewise, the Standard's systematic organization of its marketing areas with a system of espionage over its competitors' business was a factor of no little importance in the Standard's securing and maintaining its monopoly control.

Fifthly, as to restraint by control of pipe lines. In its efforts to secure and maintain control of the pipe lines of the country the Standard resorted to numerous and varied devices. One method utilized was to interfere with the construction of independent pipe lines either by purchasing land along the proposed routes of the independents or by securing rights of way of its own across such routes. Frequently the support of railroads was enlisted and thereupon these would refuse to extend rights of way across their tracks to rivals of the Standard. In States where pipe lines were given the right of eminent domain, this would cause nothing more than delay, litigation, and expense; but in

[1] Bureau of Corporations, *op. cit.*, part I, p. 24.
[2] *Ibid.*, p. 23.
[3] *Ibid.*, p. 330.

States where pipe lines were not extended this right, it served effectually to defeat the independent pipe-line projects.[1] Another method employed several times by the Standard interests was to obtain control of independent pipe-line enterprises by purchasing a part of their stock.[2] A method more frequently resorted to was to force independents out of business by paying premiums on crude oil at the wells to those producers in the immediate vicinity of an independent line. In view of the wide scope of the Standard's operations, the Company could afford to practice price discriminations of this sort in limited areas where competition may have been especially keen without influencing to an appreciable degree the average price which it paid. The small competitor, however, in meeting this competition on all or a major portion of his business frequently did so at an absolute loss. In some instances, in order not to prejudice its business at other points, the Standard organized 'bogus' independent companies in whose name the discriminating practices were conducted.[3] When these methods failed in their objects the Standard in some instances purchased outright the oil wells or refineries upon which independent pipe lines were wont to depend for their continued existence. Either expedient served to deprive the pipe line of the business which it had formerly handled. In the one case, the transportation company lost the source of its traffic; in the other, its customers for the purchase of the crude transported. And all along, the Standard consistently refused either directly or indirectly to transport oil for other than Standard refineries. The passage of the Hepburn Act in 1906 was designed to remedy this situation. The act declared pipe lines doing an interstate traffic to be common carriers, and as such subject to the jurisdiction of the Interstate Commerce Commission. The law was evaded, however, by one subterfuge or another

[1] Bureau of Corporations, *op. cit.*, part 1, p. 25.
[2] *Ibid.*
[3] *Ibid.*, p. 26.

and, until after the dissolution of the Standard in 1911, its pipe lines had never acted as common carriers.[1]

Sixthly, as to the ability of the Standard to locate its refineries at strategic points. This followed directly from the Standard's control of pipe lines and was a significant factor in its maintaining a monopoly of the refining and marketing end of the industry. Pipe-line transportation is very much cheaper than railway transportation, and its control enabled the Standard to deliver the refined products to population centers at a much lower cost than could independents who were forced to rely upon railways as a transportation agency. Such competitors were forced either to locate their refineries in the oil-field regions, and pay freight on the refined products to centers of population; or to locate their refineries at the marketing centers, and pay railway charges on crude oil to the refineries. The differential advantage which this situation has given the Standard is set forth in the following table comparing railway tariffs per barrel, in 1915, with pipe-line tariffs per barrel.[2]

The significance of this differential in favor of pipe-line transportation as against railway transportation is emphasized by the fact that transportation charges are a very important factor in the price of crude oil at its destination. For example, during 1915, the price of Mid-Continent crude oil at the well varied from $1.20 to 40 cents per barrel.[3] The pipe-line rate to Neodesha, Kansas, was 20 cents per barrel, or from 16.7 per cent to 50 per cent of the price of oil at the well; while the railway rate was 31 cents or from 25.8 per cent to 77.5 per cent of the price of oil at the well. The pipe-line rate to Whiting, Indiana, was 42 cents, or from 35 per cent to 105 per cent of the price of oil at the well; while the railway rate was $0.622, or from 51.8 per cent to 155 per cent of the price of oil at the wells. And finally, the

[1] Bureau of Corporations, *op. cit.*, part 1, pp. 26–29. For a discussion of the methods of evading the Hepburn Act, see Chapter VI.

[2] Federal Trade Commission, *Report on Pipe-Line Transportation of Petroleum* (Washington, 1916), p. 23.

[3] *Ibid.*, p 24.

TABLE 1. COMPARISON OF RAILWAY TARIFFS WITH PIPE-LINE TARIFFS ON CRUDE OIL IN 1915 FROM THE CUSHING POOL TO SPECIFIED POINTS

SHIPPING POINT	DESTINATION	RAILROAD RATE PER BARREL	TRUNK PIPE-LINE RATE PER BARREL	MARGIN BETWEEN RAILROAD AND PIPE-LINE RATES
Cushing Pool	Neodesha, Kan.	$0.311	$0.200	$0.111
Cushing Pool	Sugar Creek, Mo.	.373	.280	.093
Cushing Pool	Woodriver, Ill.	.544	.340	.204
Cushing Pool	Whiting, Ind.	.622	.420	.202
Cushing Pool	Cleveland, Ohio	.979	.580	.399
Cushing Pool	Pittsburgh, Pa.	1.054	.590	.464
Cushing Pool	Buffalo, N.Y.	1.054	.590	.464
Cushing Pool	Philadelphia, Pa.	1.348	.700	.648
Cushing Pool	Marcus Hook, Pa.	1.348	.685	.663
Cushing Pool	Baltimore, Md.	1.320	.700	.620
Cushing Pool	Bayonne, N.J.	1.403	.700	.703
Cushing Pool	Constable Hook, N.J.	1.403	.700	.703
Cushing Pool	New York City (Brooklyn)	1.403	.700	.703
Cushing Pool	West Dallas, Tex.	.392	.200	.192
Cushing Pool	Fort Worth, Tex.	.329	.275	.054
Cushing Pool	Port Arthur, Tex.	.466	.400	.066

pipe-line rate to New York City was 70 cents, or from 58.3 per cent to 175 per cent of the price of oil at the well; while the railway rate was $1.40, or from 116.7 per cent to 350 per cent of the price of crude oil at the wells.

And finally, as to the advantage which comes from large-scale operations in the oil industry. It is frequently contended that one of the chief influences which gave force to the general movement toward combination in industry during the closing decades of the nineteenth century was the desire to secure economies which presumably inhere in large-scale production. This is not the place for an extended discussion of the merits of this contention. A study of the character of the petroleum industry, however, does indicate that once the Standard's monopoly control was established, its larger scale of operations afforded economies which served to fortify further its position of power. This

seems particularly true of its pipe-line and refinery operations. There is no doubt that the Standard's larger pipe-line system could be operated more economically than the smaller lines of the independents.[1] Likewise, the greater number of its refineries and the larger scale of operations at particular plants enabled it to do business at a lower cost than could the smaller independents. Its refineries were scattered widely over the country and were conveniently located with reference to population centers. Thus in 1906 the Standard Oil Company controlled the output of twenty refineries located in twelve different States. The Standard was thereby enabled to keep its transportation charges low on refined products through the elimination of cross-freights. The larger size of the individual plants — the Standard's Bayonne refinery and its Philadelphia refinery each distilled 50 per cent more illuminating oil in 1904 than all the independents combined — undoubtedly contributed, also, to its economic superiority. A large-scale plant can afford to install the apparatus necessary to extract from petroleum its full range of values. This fact gives it an advantage over the small plant. While there are, no doubt, limits beyond which no increase in economy is secured by enlarging the plant, these limits seem not to have been reached by most of the independent competitors.[2]

Such in brief are the factors which have permitted the Standard's monopoly control of the petroleum industry. Of equal importance from the public viewpoint is the resulting economic effect of such control, particularly as it has affected the consumer from the price standpoint.

The Standard Oil Company credits its monopoly control to its superior efficiency and its reduction of prices. John D. Archbold, vice-president, set forth this claim in his testimony before the Industrial Commission in 1899 in the following language:[3]

[1] For a discussion of the advantages of large-scale operations in pipe-line transportation, see Chapter XI.

[2] Bureau of Corporations, *op. cit.*, part II, p. 650.

[3] *Ibid.*, p. 615.

I speak to-day especially in defence of the aggregation of capital and experience in the petroleum business on the ground of its absolute necessity for the successful development and promotion of that business. I am here to defend the Standard Oil Company organization also on economic and ethical grounds. . . .

It improved quality and greatly reduced costs. It supplanted old and inferior methods and refineries with the newest and most progressive methods and most perfectly equipped and favorably located refineries. . . .

It is true beyond a question that the result to the public of the operations of the Standard Oil Company has been highly beneficial, and not hurtful, as its enemies claim. As has been already stated, it has given the public goods of vastly improved quality at greatly reduced prices. It has, by its effective system of distribution, supplied this most necessary article for domestic consumption promptly and cheaply to the most remote sections of our country, and, indeed, to the world.

John D. Rockefeller voiced a similar note before the same organization: 'I ascribe the success of the Standard to its consistent policy to make the volume of its business large through the merits and cheapness of its products.' [1]

Such testimony is to be accepted for all it may be worth. The Bureau of Corporations in its report of its investigations of the Standard, submitted in August, 1907, calls into question the validity of these claims, and endeavors to substantiate its position by a careful analysis of price movement over a period of years. This analysis includes a study of the increase in margins between the prices of Pennsylvania crude oil in cents per gallon and the prices of four of its chief products, illuminating oil, gasoline, lubricating oil, and paraffin wax.[2] The figures indicate that from 1897 to 1903 the margin of each of these products moved upward. For example, the margin of illuminating oil increased from 5.3 cents per gallon in 1898 to 7.1 cents in 1903 — an increase of 1.8 cents or 34 per cent. The gasoline margin increased from 5.2 cents in 1898 to 9.2 cents in 1903 — an increase of 4 cents, or 77 per cent. The lubricating margin increased

[1] Bureau of Corporations, *op. cit.*, part II, p. 616.
[2] *Ibid.*, p. 10.

from 10.7 cents in 1898 to 13.7 cents in 1903 — an increase of 3 cents, or 28 per cent. During the same period the margin on paraffin wax increased from 26.9 cents to 31.9 cents — an increase of 5 cents or 18.6 per cent. During these years the price of crude oil had increased approximately 60 per cent. This fact accounts in part for the increase in the price of petroleum products; but the price of the products was advanced with sufficient rapidity for the margins to show a consistent tendency upward. A weighted average of the combined price of the four products is also given, together with the margin of the average above the crude prices. This margin shows an increase of from 6.5 cents in 1898 to 8.8 cents in 1903 — an increase of 2.3 cents, or almost 36 per cent. This increased margin, as well as the increase in the margins of the separate products over the crude, indicates a corresponding increase in profits per gallon of product, except to the extent that the increase has been offset by an increase in the cost of refining. The Bureau of Corporations, after an analysis of cost figures, concludes that an increase in the cost of operating expenses had not exceeded 10 per cent. Twenty-five per cent would be a marked overestimate. 'Nevertheless, even if the increase from 1897 or 1898 to 1903 and 1904 had been 25 per cent it would amount to only about one half cent per gallon.' [1]

Not only did the margin between refined and crude prices show an increase during this period, but according to the figures presented in the Standard Oil trial before the United States Supreme Court, prices of the chief refined products in cents per gallon also advanced both absolutely and relatively to the general price level. For example, the combined average price of the principal refined products increased from an average of 6.46 cents, for the period from 1895 to 1898, to an average of 9.42 cents, for the period from 1903 to 1906. This represents an increase of 2.96 cents or 45.8 per cent in the price of petroleum products, while the

[1] Bureau of Corporations, *op. cit.*, part II, p. 14.

general price level during this same period increased only 26.6 per cent.[1]

The significance of the increase in price per gallon can best be appreciated in the light of the enormous output of the Standard. The average increase in profit on the products of Pennsylvania and Lima crude from 1898 to 1904, with due allowance for an increase of one half cent per gallon in operating costs, was 1.5 cents per gallon. The entire refined output of the Standard in 1904 was about 1,400,000,000 gallons. Thus the increased margin during the six-year period resulted in increased profit to the Standard of about $21,000,000 during 1904.

A study of the profits of the Standard during the period under consideration indicates the accuracy of the foregoing conclusions. In the words of the Bureau of Corporations:[2]

> As far as can be determined from the available evidence, moreover, the profits during recent years have been much higher in relation to investment than during earlier years, as might be expected from the advance in the margin between the prices of finished petroleum products and prices of crude oil.

But a proper appreciation of the profits of the Standard during this period necessitates a glance at the value of the original investment, for profits are relative and are best expressed as percentages. The trust organization of 1882 issued trust certificates to the amount of $70,000,000 in exchange for the stock of forty companies, the actual value of which was placed by the Trust at $55,710,698. Subsequent to the organization of the Trust, the Standard issued additional certificates to the amount of $12,225,400 for cash or property, giving a total value of $67,936,098 to the entire property held by the trustees, aside from property accumulated out of the profits. Adding to this an issue of $1,088,382 of stock subsequent to the reorganization of the Standard

[1] Standard Oil Company of New Jersey, *et al. vs.* United States of America. In the Supreme Court of the United States, *Brief for the United States*, vol. II, p. 45.

[2] Bureau of Corporations, *op. cit.*, part II, p. 39.

Oil Company of New Jersey, and assuming that this additional stock was paid for at par in cash or property, the total investment of the Standard Oil Company amounted to $69,024,480 by 1906.[1] This is exclusive of reinvested earnings.

Let us now consider the earnings of the Standard since 1882. During a period of twenty-five years a total of $551,992,000 was declared in cash dividends. During this time the rate of dividends on the capital stock, which in 1882 was $14,289,301 in excess of the actual value of the property as estimated by the Trust itself, showed an increase of from 5.25 per cent to a maximum of 48 per cent, the ten-year average rate from 1897 to 1906 being approximately 40 per cent. The total net earnings as related to capital stock increased during the same period from 17.4 per cent to 84.5 per cent. The average for the decade 1882 to 1891 was 16.1 per cent; from 1892 to 1899 it was 32.2 per cent; while during the last period of seven years, 1900 through 1906, the average annual return was over 66 per cent.[2] Obviously, a large portion of the net earnings went back into the business in extensions, enlargements, etc., incidental to the normal growth of the oil industry subsequent to the establishment of the monopoly. The annual mean of assets increased from $60,516,000 in 1882 to $337,506,000 in 1906. Notwithstanding this enormous increase in the value of the Standard holdings, represented by reinvested surplus, the rate of earnings on assets showed a substantial increase during the life of the Standard Oil Trust. The average rate of net earnings to assets for the first decade of the Trust's life was 15.1 per cent. The following eight years showed an increase in the annual rate to 21.1 per cent, while the period from 1900 to 1906 showed an increase to 25.2 per cent.[3]

The foregoing facts and figures are persuasive if not convincing. On their face they indicate that the Standard exercised its monopoly power to increase its profits at the

[1] *Brief for the United States, op. cit.*, vol. II, pp. 4–5.
[2] *Ibid.*, pp. 6–11. [3] *Ibid.*, p. 11.

expense either of the consumer or producer, or perhaps both. It should be observed, however, that the widening margin of profit occurred during a period when the general price level was rising. It may have been, therefore, the result in part of the normal tendency for the price of raw materials to lag somewhat behind that of finished products. Such a large and sustained increase would hardly seem normal, however, for a five-year period. Increasing profits in the fabrication of oil products under competitive conditions would normally have led to such an increase in the price of raw materials as to adjust the price of refined products to a cost-of-production basis. In this regard it might be contended that the increased margin was merely a reflection of the growing efficiency of the Standard Oil Company over its smaller and marginal competitors with whose cost of production price tended to conform. Such an argument, however, is far from convincing. With the Standard already in control of approximately 87 per cent of the traffic in refined products, and from year to year widening its margin of profit through greater efficiency of operation, it is difficult to see how high-cost producers could survive. We should expect the Standard through sheer efficiency to increase its monopoly to approximately a 100 per cent basis. Granting that the Standard was perhaps the most efficient concern in the oil business, such a tremendous rate of profit as it was apparently enjoying, in the absence of the restraining influence of the Standard's customary 'unfair' practices, would normally have attracted capital into the industry in such large amounts as to permit operation on such a scale as to establish genuine competition with the Standard. Such competition, on theoretical grounds, should have resulted in a decrease in the margin of profit such that the return on capital invested therein would have corresponded with the normal rate of competitive enterprises. The Standard, as evidenced by its continued use of what have come to be regarded as unfair practices, seems to have been unwilling to risk its continued dominance of the industry

upon its alleged economic superiority. It seems clear to the writer that the widening margin of profit, together with its increasing rate of profit, can more logically be credited to the Standard's monopoly position which enabled it to exert a dominating influence in price changes of both raw materials and finished products.[1]

Thus far in the inquiry we have attempted to trace very briefly (1) the historical stages by which the Standard's monopoly control in the oil industry was established, (2) the methods pursued in the establishment of this control, and (3) the economic effects of this control in terms of price and profit. We have seen that by 1879 the Standard had established its supremacy in the petroleum industry in all its branches save only production. Its success must be credited in part to the business ability of the men who directed its operations; and to the fact that, once the Standard had acquired a monopoly control, it had a distinct advantage over its competitors through the economies which were effected by large-scale operations. Neither of these factors, however, seems sufficient to account for the degree of monopoly power actually realized by the Standard. To the methods and policies pursued, to the practices employed in its fight against independents, it would seem the major share of the credit or blame must be given. The growing conviction on the part of the public that the Standard's monopoly of the industry had been illegally maintained by unfair practices and that it had resulted in monopoly profits at the expense of the consumer occasioned much antagonism to the Standard organization. The growing feeling of antipathy is summed up in the letter of Commissioner Smith of the Bureau of Corporations, in submitting the report of the Bureau in 1907 [2]:

> The Standard has superior efficiency in running its own business; it has an equal efficiency in destroying the business of its com-

[1] For a fuller treatment of the Standard's influence on prices, see Chapter VI.

[2] Bureau of Corporations, *op. cit.*, part II, p. xlv.

petitors. It keeps for itself the profits of the first and adds to these the monopoly profits secured by the second. Its profits are far above the highest possible standard of a reasonable commercial return, and have been steadily increasing. Finally, the history of this great industry is a history of the persistent use of the worst industrial methods, the exaction of exorbitant prices from the consumer, and the securing of excessive profits for the small group of men who over a long series of years have thus dominated the business.

CHAPTER IV

THE DEVELOPMENT OF THE FEDERAL ANTI-TRUST POLICY

Our modern economic organization is frequently designated the 'competitive system.' The 'competitive system' as thus conceived has two marked characteristics. It is a system of pecuniary rivalry based on the institution of private ownership, a system in which individual initiative has free play and private ownership is accepted as a natural right. Within this system the material resources of modern society have been developed under the individual guidance of business men who control them by virtue of ownership. The motive of these business men has been the desire for private gain. It has manifested itself in competitive business rivalry.

The competitive system had its inception in a less complex industrial situation in which the handicraftsman occupied the foreground both as business man and workman. A petty trade or commercial traffic among the handicraftsmen marked the beginning of modern business enterprise. The Industrial Revolution and the factory system hastened its development. On its spiritual side the competitive system seems to have been the outgrowth of the 'natural rights' philosophy of the seventeenth century. But habits of thought change more slowly than do the material circumstances of life, and ideas may be tenaciously retained chiefly because they are familiar. Thus, despite the significant changes which have taken place in our industrial situation a bias in favor of the competitive system remains firmly implanted in modern society. It may be that this bias is justified by the industrial accomplishments of competitive enterprise. On the other hand, the increasing complexity of our economic organization may have oc-

casioned the need of a modification at some points of our traditional attitude toward industry.

It has been said that the 'spiritual attitude of a given generation of economists is . . . in good part a special outgrowth of the ideas and preconceptions current in the world about them.' [1] Whether or not this is true, the whole framework of modern economic theory has been constructed on the foundations afforded by the principles of the competitive system. The institutions of private property and competitive pecuniary rivalry are accepted as unquestioned premises. A value theory becomes the central tenet of a science of economics. Pecuniary rivalry, actuated by the motive of private gain, is the force, actual and desirable, which energizes the distributive process. To the extent that competition works without lag or friction, the accepted principles of nineteenth-century economics hold true. Any obstruction to the free working of economic laws concerning value, price, and distribution is regarded as exerting a 'retarding influence' upon industrial development, as a 'perversion of the forces of progress.' 'If nothing suppresses competition, progress will continue forever.' [2] But the past three decades have witnessed a tendency toward concentration in the control of industrial enterprise. The normal outgrowth of unrestricted competitive business enterprise, with profit as its driving force and ultimate goal, has been some form of combination tending toward monopoly control. At any rate, this has been true of a sufficiently large number of our basic industrial enterprises to give the present industrial era its characteristic tone. Meanwhile, these combinations have been guilty of practices detrimental to the public welfare. Hence, they have come to be regarded as 'economic perversions,' 'modern Molochs,' which are to be condemned and destroyed.

[1] Veblen, Thorstein, *The Place of Science in Modern Civilization* (New York, 1919), p. 86.

[2] Clark, J. B., *The Essentials of Economic Theory* (New York, 1907), pp. 374–75.

There is in many quarters an impression that monopoly will dominate the economic life of the twentieth century as competition has dominated that of the nineteenth. If the impression is true, farewell to the progress which in the past century has been so rapid and inspiring. The dazzling visions of the future which technical gains have excited must be changed to an anticipation as dismal as anything ever suggested by the Political Economy of the classical days — that of a power of repression checking the upward movement of humanity and in the end forcing it downward. No description could exaggerate the evil which is in store for a society given hopelessly over to a régime of private monopoly. . . . Monopoly checks progress in production and infuses into distribution an element of robbery. It perverts the forces which tend to secure to the individuals all that they produce. It makes prices and wages abnormal and distorts the forms of the industrial mechanism.[1]

All this it may do and more, but our chief interest in this rather eloquent plea for the righteousness of the competitive system is the fact that it sums up in the words of one of the leaders of modern economic thought the accepted common-sense attitude toward the monopoly problem at the opening of the twentieth century. The way out leads backward, of course, but it is over familiar ground and we travel with confidence.

The trust movement began in America in the latter quarter of the nineteenth century. The Standard's agreements of 1879 and 1882 mark the formation of the first real monopolistic organization. Pooling arrangements, gentlemen's agreements, etc., were common prior to these dates; but as monopolistic enterprises they worked imperfectly and spasmodically. The quarter of a century following the organization of the Standard was marked by a pronounced tendency toward integration and combination in the industrial world. So rapidly had the movement progressed that by 1904 there was an invested capital in this country of $7,246,000,000 controlled by some 318 combinations. Ten of these each had a capital stock of $100,000,000 or more, thirty each had a capital stock of $50,000,000 or more, while 129 each had a capital stock of $10,000,000 or

[1] Clark, J. B., *op. cit.*, pp. 374–75.

more. Twenty-six organizations controlled 80 per cent or more of the total output of products with which they were concerned, fifty-seven controlled 60 per cent or more, and seventy-eight controlled 50 per cent or more.[1]

The methods and practices employed in effecting concentration and control in these various monopolistic enterprises were in several instances quite similar to those practiced by the Standard organization. Frequently the railways were involved in some sort of discrimination in regard to freight rates, rebates, etc. To a sensitive public, and to the injured parties in particular, such practices seemed unfair and undesirable. Public opinion was aroused. As early as 1872, following the disclosure of the plans of the South Improvement Company, a Congressional investigation was requested and secured by the Petroleum Producers' Union which had been organized as an expression of opposition to the former concern. In 1874 the Windom Committee was appointed by Congress to investigate railroad practices. In its report, the Committee recommended publicity of rates and the establishment of a Court of Commerce as a remedy for the evils of discrimination. In April of the same year, as a result of the above report, the first interstate commerce bill was introduced in the House.

In 1877 the Second Petroleum Producers' Union was organized because of the great discrepancy between the prices of refined petroleum products and of crude petroleum, a situation which was believed to have been brought about through the Standard's control. One result of the agitation of this organization was a revival of the demand for interstate commerce legislation. In May, 1878, the Reagin Bill passed the House, only to be smothered in the Senate. At the same time the Pennsylvania legislature was besieged with requests for the passage of a pipe-line bill and an anti-discrimination bill.

Nor were the independent oil interests alone in their efforts to secure reform. Freight discrimination was a

[1] Moody, John, *The Truth About the Trusts* (New York, 1904), p. 486.

common practice in the transportation of other products and consequently requests for investigations were numerous. In 1878 the New York Chamber of Commerce demanded an investigation by the legislature, and as a result the Hepburn Commission was appointed. At about the same time an investigation was begun in the State of Ohio. These investigations accomplished little in the way of concrete remedial measures, but they served further to crystallize public opinion. It was not until 1887, however, that Congress finally went on record with the passage of the Interstate Commerce Act.

In the meantime, so flagrant had become the abuses of the 'big interests' that public opinion was thoroughly aroused. Periodicals were flooded with articles on the subject. The titles of a few of these articles reflect the temper of the times. 'Modern Feudalism,' by J. F. Hudson, appeared in *The North American Review* for March, 1887; 'The Moloch of Monopoly,' by William Barry, in *The Forum* for June, 1889; 'The Bugbear of Trusts,' by Henry Wood, in the same publication in July, 1888. George Gunton, writing in the *Political Science Quarterly* for September, 1888, characterizes the frame of mind of the public toward the monopoly problem in the following words: 'Indeed, the public mind had begun to assume a state of apprehension, almost amounting to alarm, regarding the evil economic and social tendencies of these organizations.' [1]

In response to this outcry, the political parties turned their attention to the matter in their platforms of 1888. The Republican Party formulated its opposition to the growing power of large industrial enterprises in the following words: [2]

> We declare our opposition to all combinations of capital, organized in trusts or otherwise, to control arbitrarily the conditions

[1] Quoted by Knauth, O. W., *The Policy of the United States Towards Industrial Monopoly* (New York, 1913), p. 14.

[2] McKee, T. H., *The National Conventions and Platforms of all Political Parties* (Baltimore, 1906), p. 241.

of trade among our citizens; and we recommend to Congress and the State legislatures, in their respective jurisdictions, such legislation as will prevent the execution of all schemes to oppress the people by undue charges on their supplies, or by unjust rates for the transportation of their products to market.

The Democratic platform was no less pronounced in its condemnation of the existing situation in industry.

Judged by Democratic principles, the interests of the people are betrayed when, by unnecessary taxation, trusts and combinations are permitted to exist, which, while unduly enriching the few that combine, rob the body of our citizens by depriving them of the benefits of natural competition.[1]

The outcome of the foregoing campaign pledges was the passage of the Sherman Anti-Trust Act in July, 1890. The bill had been introduced by Senator Sherman of Ohio on December 4, 1889. The Congressional debates reëchoed the sentiment of the times in regard to the disappearance of competition. Senator Sherman, in the course of his defense of the measure, expressed his attitude in the following language:[2]

Associated enterprise and capital are not satisfied with partnerships and corporations competing with each other, and have invented a new form of combination commonly called 'trusts,' that seeks to avoid competition by combining the controlling corporations. . . . The sole object of such a combination is to make competition impossible. It can control the market, raise or lower prices as will best promote its selfish interests, reduce prices in a particular locality and break down competition, and advance prices at will where competition does not exist. Its governing motive is to increase the profits of the parties composing it. . . . It is a substantial monopoly injurious to the public, and by the rule of both common law and civil law is null and void and the just subject of restraint by the courts; of forfeiture of corporate rights and privileges and, in some cases, should be denounced as a crime, and the individuals engaged in it should be punished as criminals. It is this kind of a combination we have to deal with now.

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[1] McKee, T. H., *The National Conventions and Platforms of all Political Parties* (Baltimore, 1906), p. 238.

[2] Walker, Albert H., *The History of the Sherman Law of the United States of America* (New York, 1910), pp. 13–14.

Senator Gore, of Oklahoma, while opposed to the particular measure under consideration, voiced a similar note in the following words: [1]

> These trusts and combinations are great wrongs to the people. They have invaded many of the most important branches of business. They operate with a double-edged sword. They increase beyond reason the cost of the necessaries of life and business, and they decrease the cost of the raw material, the farm products of the country. They regulate prices at their will, depress the price of what they buy, and increase the price of what they sell. They aggregate to themselves great enormous wealth by extortion, which makes the people poor. Then making this extorted wealth the means of further extortion from their unfortunate victims, the people of the United States, they pursue unmolested, unrestrained by law, their ceaseless round of peculation under the law, till they are fast producing that condition of our people in which the great mass of them are servitors of those who have this aggregated wealth at their command.

Such homiletical discourses are interesting chiefly because they reveal a prevailing sentiment, a characteristic attitude, a frame of mind. They are also interesting because of the fact that the sentiments expressed crystallized in the shape of the Sherman Anti-Trust Act. Section 1 of the measure as finally passed, provides that 'every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or foreign nations, is hereby declared illegal.' Section 2 provides that 'every person who shall monopolize or attempt to monopolize or combine or conspire with any other person or persons to monopolize any part of the trade among the several States or with foreign nations, shall be deemed guilty of a misdemeanor.' Penalties are provided for the violation of either section.

The wave of anti-trust sentiment which on its crest carried through Congress the foregoing measure broke into ripples of State action. Trust investigations swept over the entire country. Among these was the investigation of the activities of the Standard Oil Company, undertaken by

[1] Walker, *op. cit.*, pp. 14–15.

the New York Senate in February, 1888. The New York Assembly followed in March with similar action. The net outcome seems to have been only a report in which it was suggested that the Standard Oil Trust was a 'shrewd and slippery device for evading responsibility.' There the investigation seems to have stopped.[1]

But the Standard Oil Trust was not permitted to operate unmolested. An investigation of a more serious and determined nature was begun in Ohio in May, 1890. A petition was filed against the Standard averring that by transferring 34,993 shares of its 35,000 shares of stock to the Trustees of the Standard Oil Trust, the Standard Oil Company of Ohio was guilty of acts *ultra vires*. The petition further alleged that in 'violation of law and in abuse of its corporate power, and in the exercise of privileges, rights, and franchises not conferred upon it, the defendant company had become a party to the trust agreements of 1882.'[2] The trial extended over about two years, was filled with elaborate argument, and in March, 1892, the Court rendered a decision declaring the Standard Oil Company guilty. Its charter, however, was not declared forfeit, but the Company was ordered to sever its connection with the Trust. The board of trustees thereupon became a liquidating board for the ostensible purpose of effecting a dissolution of the trust organization. The methods chosen were simple, but equally ineffective, and were apparently designed to accomplish nothing except by way of evasion and subterfuge. Stock in the constituent companies was to be returned to the original owners; but on a pro-rata basis according to the number of trust certificates held. Since the board of trustees, consisting of nine members, formerly owned a majority of trust certificates, by effecting such an exchange they now owned a majority of the stock in each of the constituent concerns. Each hand received a new deal, but care was taken not to shuffle the cards. Nor were all the cards redealt. Exchanges took place

[1] Tarbell, Ida, *op. cit.*, pp. 129 *et seq.*
[2] Montague, G. H., *op. cit.*, p. 110.

slowly, and by 1897 only about one half of the 972,500 trust certificates had been exchanged.

The State of Ohio, under the leadership of its energetic attorney-general, Mr. F. S. Monnet, thereupon began prosecution of the Standard Oil Trust on the grounds of contempt of court. Meanwhile, the Standard Oil Trust sought refuge from these suits in the New Jersey corporation law. In June, 1899, the Standard Oil Company of New Jersey increased its capital stock from $10,000,000 to $110,000,000 and proceeded to absorb the smaller Standard companies by exchanging the outstanding trust certificates and shares of stock of subsidiaries for shares in the New Jersey holding company. Obviously, the reorganization, since it was a change of form only, resulted in no essential change in the position of the Standard in the oil industry. Individuals who had previously held a controlling interest in the old trust certificates now held a majority of stock in the New Jersey corporation, the former trustees becoming directors in the new organization. The contempt proceedings were dropped, however.

Meanwhile, the citizens of the country were growing restless under the pressure of rising prices and the renewed trend toward concentration and combination in industry which followed the depression of 1893. In 1900 the Republican platform responded to this growing uneasiness in the following words:[1]

> We recognize the necessity and propriety of the honest co-operation of capital to meet new business conditions, and especially to extend over rapidly increasing foreign trade; but we condemn all conspiracies and combinations intended to restrict business, to create monopolies, to limit production, or to control prices, and favor such legislation as will effectively restrain and prevent all such abuses, protect and promote competition, and secure the rights of producers, laborers, and all who are engaged in industry and commerce.

The Democrats, equally responsive to the voice of the

[1] McKee, *op. cit.*, pp. 342–43.

populace, took their position beside the Republicans and expressed condemnation of the growing concentration in the control of industry as follows: [1]

> Private monopolies are indefensible and intolerable. They destroy competition, control the price of all material and of the finished product, thus robbing both producer and consumer. They lessen the employment of labor and arbitrarily fix the terms and conditions thereof, and deprive individual energy and small capital of their opportunity for betterment. They are the most efficient means yet devised for appropriating the fruits of industry for the benefit of the few at the expense of the many, and unless their insatiate greed is checked, all wealth will be aggregated in a few hands and the Republic destroyed.
>
> . . . . . .
>
> We pledge the Democratic party to an unceasing warfare in Nation, State and city against private monopoly in every form.

In 1903, under Republican leadership, the Bureau of Corporations was established as an investigating body to function under the direction of the newly created Department of Commerce and Labor. Its duties were to investigate the affairs of corporations engaged in interstate commerce. Soon after its organization, it began an investigation of the activities of the Standard Oil Company. The first report on this organization covered the field of transportation. It was submitted by the commission in May, 1906. Soon afterwards a two-volume report covering the entire petroleum industry was made public. This is a comprehensive and detailed analysis of the history and activities of the Standard. In the investigation special attention was directed toward the extent of the Standard's monopoly control and the methods by which this control had been secured.

As a result of this investigation, prosecution proceedings were instituted by the Department of Justice against the Standard Oil Company in the United States Circuit Court, Missouri district. A bill was filed in November, 1906,

[1] McKee, *op. cit.*, pp. 334–36.

alleging violation of the Sherman Anti-Trust Act of 1890. The trial extended over a period of approximately three years. The testimony and records filled some twenty-three volumes and covered more than twelve thousand pages. Facts established during the trial indicated that the Standard Oil Company of New Jersey owned directly stock in sixty-five companies and controlled indirectly, through ownership of stock in subsidiaries, forty-nine other companies, a total of one hundred and fourteen concerns. In the original bill, seventy-one corporations and seven individuals had been named as defendants. A decision was handed down in November, 1909. The decree ran against the Standard Oil Company of New Jersey, thirty-six domestic subsidiaries and one foreign subsidiary.[1] The court held that the stock of these thirty-seven corporations was acquired and held by means of illegal combination in violation of the Sherman Act. Accordingly, the Standard was enjoined from voting the stock of these subsidiary companies and from exercising or attempting to exercise control over their actions. The subsidiary companies were also enjoined from paying dividends to the parent organization. Dissolution of the combination was ordered. The dissolution was to be effected by distribution on a pro-rata basis to the shareholders of the principal company 'the shares to which they are equitably entitled in the stocks of the defendant corporations that are parties to the combination.'[2]

Appeal was made by the Standard to the Supreme Court of the United States. The decision was handed down in May, 1911. Chief Justice White in setting forth the opinion of the Court reviewed briefly the intent of the anti-trust law:[3]

[1] The bill was dismissed as to the other corporate defendants, thirty-three in number; these were adjudged not to have 'been proved to be engaged in the operation or carrying out of the combination.' Of the dismissed defendants sixteen were natural-gas companies and ten were companies which had been liquidated before the filing of the petition. 221 *U.S. Reports*, 45.

[2] 173 *Federal Reporter*, p. 199.

[3] 221 *U.S. Reports*, 50.

They [the debates] show, conclusively, however, that the main cause which led to the legislation was the thought that it was required by the economic condition of the times, that is, the vast accumulation of wealth in the hands of corporations and individuals, the enormous development of corporate organization, the facility for combination which such organizations afforded, the fact that the facility was being used, and that combinations known as trusts were being multiplied, and the widespread impression that their power had been and would be exerted to oppress individuals and injure the public generally.

In regard to the intent of the Standard organization to drive competition from the field and effect monopoly control the opinion states:[1]

Recurring to the acts done by the individuals or corporations who were mainly instrumental in bringing about the expansion of the New Jersey corporation during the period prior to the formation of the trust agreements of 1879 and 1882 . . . we think no disinterested mind can survey the period in question without being irresistibly driven to the conclusion that the very genius for commercial development and organization which it would seem was manifested from the beginning soon begot an intent and purpose to exclude others which was frequently manifested by acts and dealings wholly inconsistent with the theory that they were made with the single conception of advancing the development of business power by usual methods, but which on the contrary necessarily involved the intent to drive others from the field and to exclude them from their right to trade and thus accomplish the mastery which was the end in view.

. . . . . .

The exercise of the power which resulted from that organization fortifies the foregoing conclusions, since the development which came, the acquisition here and there which ensued of every efficient means by which competition could have been asserted, the slow but resistless methods which followed by which means of transportation were absorbed and brought under control, the system of marketing which was adopted by which the country was divided into districts and the trade in each district in oil was turned over to a designated corporation within the combination and all others were excluded, all lead the mind up to the conviction of a purpose and intent which we think is so certain as practically to cause the subject not to be within the domain of reasonable contention.

[1] 221 *U.S. Reports*, 75–77.

The Standard Oil Company had sinned against the competitive system and in doing so had violated the statutory laws of the land. Accordingly, the decision of the lower court was affirmed. The monopolistic combination was ordered to dissolve itself in order that competition might be restored. However commendable the law and its interpretation may have been, in its application to the oil industry, it seems to have been practically vitiated at the outset by the method of dissolution agreed upon. The stocks of the various subsidiary corporations affected by the decree were distributed to the holders of stock in the New Jersey corporation on a pro-rata basis, i.e., according to the amount of stock held in the holding company. Thus, the holders of a majority of the stock in the Standard Oil Company of New Jersey now became the holders of a majority of the stock in each of the constituent concerns, and as such exerted a controlling influence in all. But the Court had done its duty, and the Department of Justice seemed satisfied with the dissolution. Its chief efforts to enforce the anti-trust laws have since been directed toward more flagrant offenders. Meanwhile, the oil industry, notwithstanding its rather frequent investigation at the hands of governmental agencies, has been free from active Government regulation.

CHAPTER V

THE EFFECTIVENESS OF THE DISSOLUTION DECREE

Our governmental policy toward industry as shaped by the Sherman Anti-Trust Act has been designed to prevent any interference with the free play of competitive forces in business. The destruction of industrial competition was regarded by the proponents of the Act as a social calamity. It was believed that monopoly control had frequently been secured by means of unfair practices directed toward competitors; that monopoly power, when established, had been exerted in many instances to oppress individuals and the public generally; and that large profits had often been reaped at the expense of the consumer. The evidence presented in the trial of the Standard Oil Company led the Court to the conclusion that this organization was a monopolistic combination, and as such had exercised an unreasonable restraint upon trade. Hence, the decree of the Court requiring the dissolution of the Standard Oil Company in order that competitive conditions might be established. Has this effort to reëstablish competitive conditions in the oil industry been successful? Has the industry by reason of the dissolution decree been freed from the Standard's control? In the present chapter and the one following we shall attempt to answer these queries. At a later point, the question of the adequacy of our federal policy toward the oil industry will be considered. At this juncture we are interested solely in its efficacy.

As a preliminary step in the consideration of this problem, let us review the extent to which the Standard controlled the industry in the decade prior to its dissolution. In 1906, at the time prosecution proceedings were begun against the Standard Oil Company of New Jersey, the combination controlled directly the stock of sixty-five oil companies, and

indirectly, through these sixty-five companies, a majority of the stocks in forty-nine subsidiary concerns. While a few of these concerns engaged in two or more branches of the oil industry, the greater number confined their activities to one of four special lines — production, transportation, refining, or marketing. What was the extent of control exercised by the combined Standard group in each of these branches of the industry?

The production of crude petroleum, it will be recalled, has remained essentially a competitive enterprise throughout its entire development. The Standard Oil Company did not enter this branch of the industry until 1879. A decade later, the Standard produced about 16 per cent of our total national output. From 1889 until 1898 the Standard's percentage of the total domestic production showed a gradual but persistent increase until at the latter date it had reached approximately 33.5 per cent. From 1898 until 1906 the Standard's percentage of total production showed an uninterrupted decline until in 1906 the organization produced only about 11 per cent of the total domestic output.[1] This was only a small portion of the total oil consumed by Standard refineries. Its percentage of total production was greatest in the older oil regions. Thus, in 1906, while Standard companies produced only 11 per cent of the total for the country, they produced about 26 per cent of the total for the Pennsylvania fields and about 31 per cent of the total for the Lima-Indiana field.

Although oil production has always been a highly competitive enterprise, the Standard, by reason of its control of pipe lines and refineries, has been the chief purchaser and transporter of crude petroleum, and has thereby been able to control the crude product. During the decade prior to its dissolution, the Standard enjoyed substantially a monopoly control in the transportation of crude petroleum in

[1] United States *vs.* The Standard Oil Company of New Jersey, Circuit Court of the United States for the Eastern Division of the Eastern Judicial District of Missouri, *Brief for Defendant*, vol. IV, p. 95.

all fields in the United States with the exception of the Gulf Coastal and the California fields. In 1900 it transported approximately 93 per cent of all crude produced in the Appalachian field, although by 1906 its share had fallen to 83.2 per cent.[1] In the Lima-Indiana field the Standard's percentage of total crude transported was about the same as in the Appalachian field, varying from 92.9 per cent in 1901 to 89.6 per cent in 1906. Figures for the Mid-Continent field are not available, but according to evidence presented in the trial of the Standard Oil Company in 1906 there was substantially no pipe-line competition in that field. The Standard's percentage of control was said to have been much larger than in the Pennsylvania field.[2] In neither the Gulf Coastal field nor the California field did the Standard Oil Company control by pipe-line transportation the larger percentage of the production; but in both these fields the crude was of a low specific gravity, was chiefly used for fuel, and had little significance at that time in the general markets of the country for refined products.

In 1904 the Standard owned or controlled twenty-three refineries. In competition with these Standard refineries, there were seventy-five independent companies.[3] But at this time the Standard refineries together were absorbing more than 84 per cent of the total crude refined in this country and turning out about 87 per cent of the more highly refined products.[4]

Nor did the Standard group enjoy less effective control in the marketing of petroleum products. In the main, this branch of the business had been kept distinct from the other departments. The United States had been divided into eleven districts for marketing purposes, in each of which a separate Standard organization operated. In some instances, the marketing organization was but a branch or department of a company also engaged in petroleum re-

[1] *Brief for the United States, op. cit.*, vol. I, p. 141.
[2] *Ibid.*, p. 142.
[3] Bureau of Corporations, *op. cit.*, part I, p. 14. [4] *Ibid.*, pp. 14–16.

fining. In other instances, the business was turned over to a separate Standard company which purchased its refined products from one of the several Standard refineries. In each of the eleven marketing districts a Standard marketing organization operated with a distinct understanding, which was effectively carried out, that there should be no competition with the Standard companies in adjoining districts.[1] Through this effective marketing system the bulk of the total sales of refined petroleum was made. Statistics prepared by the Standard's own statistical experts indicate that for at least a decade prior to 1906 Standard organizations had marketed annually from 85 per cent to 90 per cent of the total refined products sold in the United States, Canada, and Mexico. From 1900 to 1906 the Standard's percentage of the export business in refined products was even greater, varying from 86 per cent to 91 per cent.[2]

The foregoing analysis indicates that during the decade prior to the Standard's dissolution in 1911, the organization controlled something more than 80 per cent of the business carried on in at least three branches of the industry — transportation, refining, and marketing. By reason of its supremacy in these three branches it was able to exercise a dominating influence over prices from the raw crude to the finished product.

The Court decree in 1911 forbade 'the doing in the future of acts . . . which we have found to have been done in the past which would be in violation of the statute,' and ordered the 'exertion of such measure of relief as will effectually dissolve the combination found to exist in violation of the statute, and thus neutralize the extension and continually operating force which the possession of the power unlawfully obtained has brought and will continue to bring about.'[3] The means by which this was to have been effected have already been briefly outlined. While the Standard Oil Company controlled a total of 114 companies, the final

[1] *Brief for the United States, op. cit.*, vol. I, pp. 134–38.
[2] *Ibid.*, pp. 147–49. [3] 221 *U.S. Reports*, 78.

decree in the case ran against only thirty-three of these companies. Most of those not named in the petition were either engaged exclusively in business in foreign countries or in the natural-gas business. Pursuant to the court dissolution decree, the Standard Oil Company of New Jersey mailed letters to its stockholders on July 28, 1911, announcing a ratable distribution on September 1, 1911, of the stock in thirty-three companies which it owned directly or through ownership of stock in the National Transit Company.[1] Accordingly, a ratable distribution of the stock of the following corporations was made to the stockholders of the New Jersey holding company: Anglo-American Oil Company, Limited; The Atlantic Refining Company; Borne-Scrymser Company; The Buckeye Pipe Line Company; Chesebrough Manufacturing Company, Consolidated; Colonial Oil Company; Continental Oil Company; The Crescent Pipe Line Company; Cumberland Pipe Line Company, Incorporated; The Eureka Pipe Line Company; Galena-Signal Oil Company; Indiana Pipe Line Company; National Transit Company; New York Transit Company; Northern Pipe Line Company; The Ohio Oil Company; The Prairie Oil and Gas Company; The Solar Refining Company; Southern Pipe Line Company; South Penn Oil Company; Southwest Pennsylvania Pipe Lines; Standard Oil Company of California; Standard Oil Company of Indiana; The Standard Oil Company of Kansas; Standard Oil Company of Kentucky; Standard Oil Company of Nebraska; Standard Oil Company of New York; The Standard Oil Company of Ohio; Swan and Finch Company; Union Tank Line Company; Vacuum Oil Company; Washington Oil Company; and the Waters-Pierce Oil Company.

It should be clearly borne in mind that the 'dissolution' of the Standard Oil Company of New Jersey did not involve a change in ownership of the constituent concerns. The dissolution in its essence was merely a change in the

[1] Stevens, W. S., *Industrial Combinations and Trusts* (New York, 1914), p. 462.

form of ownership. Prior to the dissolution, the several components of the Standard Oil group were owned directly by the Standard Oil Company of New Jersey, and hence were indirectly under the ownership and control of the stockholders of this organization. By the terms of the decree, the stock of the component companies was transferred to the stockholders of the parent organization who now assumed direct control of the constituents. Ownership and control ultimately remained in the hands of the same group which formerly had exercised it. With a community of ownership and interest existing among the segregated Standard units, obviously a genuinely competitive situation was not immediately established.

What is the situation to-day, fourteen years after the dissolution decree? Have the hopes of the Court been realized? Is the oil industry to-day competitive? Has oil been freed from the Standard's control? Opinion regarding these matters seems divided.

It is the contention of some men high in the oil industry, both in the Standard group and in the ranks of the independents, that the oil industry to-day is highly competitive. Mr. Henry L. Doherty, one of the leading independent oil men of the country, in an address before the American Petroleum Institute in 1920, made the following statement:[1]

> If the Standard Oil Company ever dreamed of a complete monopoly of the oil business, that dream must have left them a long time ago. In my opinion, the brains required to run their business could never have tarried this long with the idea of a sustained monopoly. They must have known that competition was inevitable and on a huge scale. . . .
>
> The oil business of this country is now, and has been for a long time, a highly competitive business; in fact, too much so for the good of the public.

Mr. A. C. Bedford, chairman of the Board of Directors of the Standard Oil Company of New Jersey, voiced a similar

[1] American Petroleum Institute, *Bulletin No. 132*, December 10, 1920, p. 48.

note in an address before the same organization in December, 1922. Competition in the oil industry is extremely severe, we are told. 'The oil industry remains essentially a free industry. Its very nature prevents monopolization or group control.' [1]

On the other hand, according to the recent report of the Committee on Manufactures to the United States Senate, the Standard's supremacy in the oil industry remains unbroken. We are told unequivocally: 'The dominating fact in the oil industry to-day is its complete control by the Standard companies. Any discussion of the subject which does not frankly recognize this control can only be misleading.' [2]

Which, if either, of these apparently contradictory opinions is correct? Are they to be reconciled? Is there a measure of truth in both? Answers to these questions, if given at all, must be postponed until a thorough analysis of developments since 1911 has been made.

In the first place, it may be well to call attention to the fact that there is to-day no single 'Standard Oil Company' coextensive with the ubiquitous Standard Oil interests. The term, as currently used, refers to the Standard Oil Company of New Jersey together with the combined group of companies which it formerly owned or controlled. In this regard, attention should be called to certain noteworthy changes which have taken place among the former constituents of the Standard Oil Company of New Jersey since the dissolution. In 1912 the Penn-Mex Fuel Company was incorporated in Delaware with a capital stock of ten million dollars. Fifty-one per cent of the stock is owned by the South Penn Oil Company, one of the Standard group affected by the dissolution.[3] In July, 1913, the Waters-Pierce Oil Company was absorbed by the Pierce Oil Cor-

[1] American Petroleum Institute, *Bulletin No. 26*, December 3, 1922, p. 8.

[2] Committee on Manufactures, *High Cost of Gasoline and Other Petroleum Products*, Senate Report No. 1263, March 3, 1923, p. 3.

[3] General Service Corporation, *Standard Oil Stocks*, 1922, p. 53.

poration, the latter concern taking over the stock formerly owned by the Standard interests.[1] The Illinois Pipe Line Company was incorporated in December, 1914, under the laws of Ohio, with a capitalization of twenty million dollars, to take over the transportation business of the Ohio Oil Company. The two hundred thousand shares of stock in this company were distributed pro rata among the holders of the six hundred thousand shares of the Ohio Oil Company.[2] The Prairie Pipe Line Company was incorporated January 14, 1915, under the laws of Kansas, with a capitalization of twenty-seven million dollars, to take over the transportation business of the Prairie Oil and Gas Company. The stock was distributed pro rata among the holders of the eighteen million dollars outstanding capital stock of this latter concern.[3] Since November 24, 1915, the Colonial Oil Company has been dissolved by a vote of its stockholders, and a payment of $150 per share made in liquidation.

This combined group of companies with the changes noted, together with the parent organization, the Standard Oil Company of New Jersey, to-day constitutes what is commonly referred to as 'The Standard Oil Company,' or the 'Standard Group.' Referring to this use of the term 'Standard,' the Federal Trade Commission, in 1917, had the following to say: 'An examination of the lists of stockholders of the various companies called "Standard" shows that they are owned by bodies of stockholders which are so similar in membership as to justify the common usage.' [4]

Since 1917 stocks of the various Standard Oil companies have played an increasingly important rôle in curb market transactions, and the stocks of four companies of the original Standard Oil group are now listed on the New York

[1] General Service Corporation, *Standard Oil Stocks*, 1922, p. 5.
[2] *Ibid.*, p. 42.
[3] *Ibid.*, p. 58.
[4] Federal Trade Commission, *Report on the Price of Gasoline in 1915* (Washington, 1917), p. 5.

Stock Exchange.[1] Likewise a number of the Standard companies have in recent years issued stock to their employees. As a result the stocks of the Standard Oil companies have become much more widely disseminated, although it still remains true that a body of stockholders similar in membership control substantial holdings in the various Standard companies. The recent report of the Committee on Manufactures[2] to the United States Senate indicates that the Rockefeller interests are the largest group stockholders in twenty-eight companies of the Standard Oil group. John D. Rockefeller, Jr., is the largest single stockholder in nine of these companies, his holdings varying from 11 per cent to 24.9 per cent of the total stock outstanding on June 30, 1922. The Rockefeller Foundation is the largest single stockholder in seventeen of the companies, its holdings of the total stock in fourteen companies being more than 20 per cent in each instance. A number of the other important stockholders owning more than 1 per cent of the total stock are holders of stock in several of the companies of the Standard group. Thus Edward S. Harkness owns more than 1 per cent of stock in twenty-seven of these companies; trustees of Henry H. Houston control more than 1 per cent in twenty companies; the Northern Finance Corporation owns more than 1 per cent in nineteen companies; Anna M. Harkness owns more than 1 per cent in eighteen companies; the General Education Board owns more than 1 per cent in nine companies; trustees of H. M. Flagler control more than 1 per cent in eight companies; the Commonwealth Fund owns more than 1 per cent in seven companies; the executors of W. L. Harkness control more than 1 per cent in six companies; the Laura Spellman Rockefeller Memorial owns more than 1 per cent in five companies; Payne Whitney owns more than 1 per cent in five companies; the Rocke-

[1] Standard Oil Company of New Jersey, Standard Oil Company of California, Atlantic Refining Company, and The Union Tank Car Company (formerly The Union Tank Line Company).

[2] Committee on Manufactures, *op. cit.*, *Hearings*, p. 1293.

feller Institute for Medical Research owns more than 1 per cent in four companies; and Mrs. Edith Rockefeller McCormick owns more than 1 per cent in two companies. The combined holdings of this more or less common group of stockholders range from 25 per cent up to 45 per cent in each of the twenty-eight companies concerning which data are available.

It should be noted, however, that these companies, despite marked community of ownership, maintain separate organizations including officers, directors, and administrative machinery. It should be noted also that most of these concerns own or control numerous subsidiaries. For example, the Atlantic Refining Company owns three subsidiaries which in turn control five other companies. The parent organization, the Standard Oil Company of New Jersey, affords the best illustration of the extended interests of the Standard group. This organization, with a capital stock of $310,000,000, owns a controlling interest in thirty-three subsidiary companies with a combined capital stock aggregating more than $200,000,000.[1]

It should, likewise, be noted that since 1918 certain members of the Standard Group have revived their former policy of expansion through the acquisition of ostensibly independent petroleum interests. Thus, in 1918, the Standard Oil Company of New York purchased a large portion of the stock of the Magnolia Petroleum Company, one of the major companies of the southern Mid-Continent area engaged in the production, transportation, refining, and marketing of petroleum.[2] Subsequently, the Standard Oil Company of

[1] General Service Corporation, *op. cit.*, pp. 89–91.

[2] The Magnolia Petroleum Company had been in reality a Standard controlled company since its organization in 1911. Over 70 per cent of the original stock was owned by H. C. Folger, president of the Standard Oil Company of New York, and J. D. Archbold, president of the Standard Oil Company of New Jersey. The stock purchased by the Standard Oil Company of New York in 1918 included the former holdings of John D. Archbold, deceased, and enough of the Folger holdings to give the New York Company 45 per cent of the total stock outstanding. Federal Trade Commission, *op. cit.*, p. 23, and General Service Corporation, *op. cit.*, p. 28.

New Jersey secured control, by stock purchase, of the Humble Oil and Refining Company with valuable producing, pipe-line and refinery properties in Texas. During 1920 the Standard Oil Company of Indiana acquired by an exchange of stock approximately 33 per cent of the stock of the Midwest Refining Company and by June, 1921, the Standard had acquired 85 per cent of the stock of the Midwest Company. This acquisition gave the Standard almost complete control of the production, pipe-line transportation, and refining properties in the State of Wyoming. Again, in 1921, the Standard Oil Company of Indiana purchased a one-half interest in the Sinclair Pipe Line Company. Thereafter, the Sinclair interests and the Standard of Indiana organized the Sinclair Crude Oil Purchasing Company. The organization of this crude-oil purchasing company and the acquisition of a half interest in the pipe-line company have enabled the Standard Oil Company of Indiana to purchase crude oil directly from the producer in the Mid-Continent field.[1]

What percentage of the total traffic in petroleum and its products is controlled by the companies which to-day make up the Standard Oil group? According to estimates presented by the Federal Trade Commission in 1919 there were about sixteen thousand producers of crude petroleum in this country. These sixteen thousand individuals or concerns produced a total of 377,719,000 barrels of crude petroleum. Thirty-two concerns each reported a production during 1919 in excess of one million barrels for a total of 218,668,000 barrels, or about 58 per cent of the marketed production of the United States.[2] Companies now members of the Standard Oil group produced 23.5 per cent of this total.[3] According to Federal Trade Commission figures recently made public the Standard Oil group produced only

[1] Federal Trade Commission, *Report on the Pacific Coast Petroleum Industry* (Washington, 1922), part II, p. 132.

[2] Federal Trade Commission, *Advance in Price of Petroleum Products*, (1920), pp. 30 *et seq.*

[3] *Pacific Coast Petroleum Industry, op. cit.*, part II, p. 15.

17.1 per cent of the total domestic production in 1922, and only 14.4 per cent in 1923.[1] It will be recalled that the Standard's percentage of total production had shown a persistent increase from 1889 to 1898 from 16 per cent to 33.5 per cent, while from 1898 to 1906 it had undergone a continuous decline to 11 per cent. This decline is to be explained in large part by the shift in centers of operation and the growing importance of the Mid-Continent area. Oil production is a highly speculative venture and changes in production areas are so rapid and frequent that the change in the Standard's position in recent years as compared with its position in 1906 does not seem to the writer to be of great significance. Nor is it of great concern to this inquiry since oil production, despite the Standard's importance in this branch, has always been a highly competitive enterprise.

In 1906 the figures showing the Standard's position in the transportation of petroleum were given by fields in percentages of total crude handled. No summary figure for either the Standard's pipe-line mileage or percentage of crude handled was available for the entire country, but, based on the figures for individual fields, it would seem to be a conservative estimate that the Standard transported from 80 per cent to 90 per cent of the total crude handled by pipe lines at that time. Its control of pipe-line mileage was probably equally great. In 1919, however, the Standard owned only 68 per cent of the trunk pipe lines of the country,[2] and probably transported a slightly larger percentage of the crude handled. Judged by these figures the Standard's proportion of total crude oil transported has shown a marked decline since 1911.

At the close of 1921 there were about 479 completed refineries in this country with a total reported daily capacity of about 2,164,050 barrels of crude oil.[3] Standard com-

[1] See *National Petroleum News*, March 4, 1925, p. 27.

[2] *Pacific Coast Petroleum Industry*, *op. cit.*, part II, p. 15.

[3] Bureau of Mines, *Petroleum Refineries in the United States*, January 1, 1922.

panies controlled about 45 per cent of this total capacity,[1] and since in general they operate more nearly at full capacity than do independents, it is probable that the consumption of Standard refineries was about 50 per cent of the total crude produced.[2] On the basis of these figures the Standard's percentage of total oil refined has shown a marked decline, since in 1904 the Standard organization consumed 84 per cent of the total crude run to refineries. Accurate figures are not available giving the percentage of refined products marketed by the Standard group. Based on their control of refined products it seems a safe assumption that Standard companies now sell approximately 50 per cent of the total petroleum products marketed, whereas at the time of the dissolution the Standard Oil Company marketed from 85 per cent to 90 per cent of the total.

These comparative figures indicate that there is a considerable element of fact in the statement quoted from Mr. Doherty at an earlier point in the discussion. Since the dissolution of the Standard Oil Company in 1911, the proportion of petroleum products handled by independent companies has shown a marked increase. The Standard has lost ground. When account is taken of the tremendous rapidity with which the petroleum industry has expanded, the relative importance of independent concerns becomes even more pronounced. To what influence is the growing prominence of independent concerns to be attributed? Does it indicate the effectiveness of the Court's dissolution decree in reëstablishing competition? While a measure of influence may properly be ascribed to this source, only indirectly was the decree a factor in bringing about the changed situation;

[1] Committee on Manufactures, *op. cit.*, p. 57.

[2] According to the Federal Trade Commission, the Standard companies refined only 44 per cent of the total in 1919. See *Report on the Pacific Coast Petroleum Industry*, part II, p. 15. The most recent Federal Trade Commission figures (see *National Petroleum News*, *op. cit.*) indicate that the Standard group of companies refined 49.8 per cent of the total domestic gasoline output in 1922 and 48.1 per cent of the total in 1923.

and any explanation which goes no further is inadequate and unavailing. Let us endeavor then to analyze the factors which are accountable for this change.

In the first place, the Standard Oil Company received a great deal of unpleasant notoriety in connection with its investigation by the Bureau of Corporations in 1906–1907 and during the court proceedings down to the dissolution decree in 1911. Publicity was given to the unfair methods employed in its attempt to destroy competition. The proceedings themselves were but a reflection of a determined attitude on the part of the Government to appease in some way the popular demand for a remedy for the evils of monopoly which for so long had been apparent. The Government's evident determination to ensure fair play to independents served as an invitation for an influx of independent capital into the oil industry.

Contemporaneously with this sterner attitude on the part of the Government toward monopoly, there occurred an enormous expansion within the oil industry. The demands upon the industry increased with such rapidity that even in the absence of governmental interference the Standard's capacity for sufficient growth would have been severely taxed. The annual production of crude petroleum in this country increased approximately 100 per cent during the decade 1881 to 1891. During the following decade, 1891 to 1901, the increase was only 28 per cent. From 1901 to 1911, however, the increase approximated 218 per cent. Notwithstanding these enormous developments during the first decade of this century, the annual production since the dissolution of the Standard has again shown an increase of more than 200 per cent. More significant than this relative increase is the increase when expressed in absolute figures. The production for the year immediately preceding the dissolution was, in round numbers, 209,557,000 barrels. In 1923 the production totalled more than 700,000,000 barrels. In the fifty-two years from 1859 to 1911 there had been produced in this country approximately 2,377,866,000

barrels of petroleum. In the decade following the dissolution of the Standard, the total production was 3,521,468,000 barrels. This phenomenal increase in oil production indicates the rapid development which the whole industry has undergone since the Standard dissolution. Into this rapidly expanding industry new capital has flowed, and this, in part, accounts for the increased importance of the group of independent petroleum companies. A rapidly expanding industry has demanded an enormous influx of additional capital. Assured of fair play and governmental protection against the former illegal practices of the Standard, independent interests have responded to the demand.

Concurrent with this increased demand placed upon the oil industry, there has occurred a shift in the territorial center of oil production. This, of itself, has rendered it less difficult for independent capital to gain a foothold. The first commercial petroleum well was completed in 1859 in Western Pennsylvania. To-day there are seven major oil-producing regions in the United States, ranking as follows: (1) Mid-Continent, embracing portions of Kansas, Oklahoma, North Central Texas, Northern Louisiana and Southern Arkansas; (2) California; (3) Rocky Mountain, including portions of Wyoming, Montana, and Colorado; (4) Gulf Coastal, embracing the coast country of Texas and Louisiana; (5) Appalachian, embracing portions of New York, Pennsylvania, Eastern Ohio, West Virginia, Kentucky, Eastern Tennessee, and Northern Alabama; (6) Illinois and Southwest Indiana; and (7) Lima-Indiana, including a portion of Northwestern Ohio and Northeastern Indiana. Thus to-day oil is produced in many different sections of the country scattered over a wide area. Until the opening of the twentieth century, however, more than 90 per cent of the crude petroleum of this country was produced in the Appalachian and Lima-Indiana fields. By 1903 California had become an important producing area, yielding approximately 25 per cent of our crude supply. California oil is chiefly of a heavy grade, however, and until recently has

not been an important factor in the refining business. Developments began in the Mid-Continent field in the decade of the nineties but were slow, and in 1904 the field yielded only 5.28 per cent of the total crude production of the country. The next three years, however, witnessed a tremendous development in this section and by 1907 the Mid-Continent territory was producing more than 28 per cent of the total for the country, a total which itself was increasing very rapidly. By 1911 the Mid-Continent's share had further increased to 30 per cent, and during the decade following the Standard's dissolution it jumped to over 50 per cent. The production in this field alone amounted in 1922 to 310,992,000 barrels, an amount more than 40 per cent greater than the total production for the entire country at the time of the dissolution of the Standard. It should be remembered that Mid-Continent crude is of a high specific gravity, and to-day is the source of the major portion of refined oil in the United States.

Thus, the entrance of independent capital into the industry has been made easy. First, independent capital has been assured that the former unfair practices would no longer be tolerated and that it would enjoy the protection of the courts in its legitimate endeavors to reëstablish competitive conditions in the oil industry. At the same time the rapid expansion of the industry has offered inviting opportunities, and the opening of virgin fields has given all comers an equal chance, except to the extent that the Standard's position of strength has given it a comparative advantage.

Independent capital has been quick to seize the opportunities. Mr. Doherty, in his address before the American Petroleum Institute, made an analysis of the fiscal operations of the major oil companies which indicates the rapidity with which independent capital has been flowing into the industry during the past decade.[1] According to the figures presented by Mr. Doherty, the capital stock outstanding on January 1, 1912, of 108 of the major com-

[1] Doherty, H. L., *op. cit.*, pp. 50 *et seq.*

panies, including most of the Standard group and the more important independents, was $682,632,909. By 1920 the capital stock outstanding of this group had been increased to $1,341,261,560. This denotes an increase of $658,628,651, of which $184,915,249 represented stock dividends and $437,317,402 represented stock issued for cash or property. This latter, together with bonds outstanding, indicated new capital of $537,601,799 entering the business through these companies. Between 1912 and 1920, 142 independent oil companies whose annual reports are available had been established as recognized going concerns. These 142 companies had a total capital stock outstanding on December 31, 1919, of $1,160,678,354. Of this amount, $19,161,263 had been issued as stock dividends. It is impossible to state what percentage of the balance, if any, represented water, but undoubtedly by 1919 a substantial proportion of the stock was covered by tangible assets with a large cash value. In addition, bonds to the amount of $105,722,821 had been issued for cash or property. The capital stock of these new independent concerns born since 1912 was more than twice the new capital stock issued by the Standard group and older independents since 1911, and in the aggregate about equaled the total capital stock of the latter group. The concerns in the foregoing groups include only the larger, well-established oil companies. The combined capitalization of all new oil and gas companies organized during the six years 1915–1920 indicates an astonishing development.

TABLE 2. SHOWING CAPITALIZATION OF ALL NEW OIL COMPANIES ORGANIZED 1915–1920

YEAR	NEW COMPANIES	CAPITALIZATION
1915	196	$80,533,000
1916	240	419,000,000
1917	512	840,000,000
1918	820	1,430,000,000
1919	1629	3,786,000,000
1920 (10 mos.)	1526	2,411,944,000
Total	4923	$8,967,477,000

It is impossible to determine to what extent the capital stock of the companies enumerated above is backed by tangible assets; and, in view of the many fraudulent promotions which have characterized the oil industry, no doubt a great many of the concerns have never functioned as going establishments. Many others have done so only for a short time and have soon passed out of existence. The capitalization of many of those that may have survived has represented in large part the hopes of the promoters rather than the actual investment of the stockholders. The figures, taken in the aggregate, however, indicate a tendency. The capital stock of these concerns, together with the stock issue of the better established concerns, whose financial reports are available, and the new financing of older independents, indicates a remarkable influx of independent capital into the industry. It suggests a return of the competitive days of pre-Standard existence. It indicates to Mr. Doherty 'the strongest possible sort of competition with the group in existence before 1912.' [1] It seems clear that in the rapid expansion that the oil industry has undergone during the last decade, independent capital has acquired a substantial foothold in the industry. The relative amount of independent capital in the industry has been on the increase and the independents to-day do a larger portion of the total oil business than at any time since the dissolution decree in 1911. That much can be safely said. But it may be well to postpone any conclusion regarding the significance of this statement until the relationship of the separate units of the Standard Oil Company has been more carefully analyzed.

Prior to the dissolution decree, the range of activities of the Standard Oil Company of New Jersey through its subsidiaries embraced every branch of the petroleum industry. Nevertheless, within the organization, there was a marked degree of productive specialization. The operations of the different stages of the industry were conducted in the main

[1] Doherty, *op. cit.*, p. 50.

by companies organized for the special activity in which each was engaged. Thus, while the parent organization owned directly extensive properties devoted chiefly to the refining and domestic marketing of petroleum, it functioned primarily as a holding company controlling the vast aggregation of properties which it comprehended. Likewise, the various constituents were in the main specialized concerns. The Prairie Oil and Gas Company, the Ohio Oil Company, the South Penn Oil Company, and the Washington Oil Company were primarily engaged in the production and purchasing of crude petroleum.[1] The transportation of petroleum was conducted by some ten companies engaged almost exclusively in this activity; and the refining and marketing of petroleum products were conducted by some seventeen companies which confined their activities exclusively to either one or both of these branches.[2] Among these spe-

[1] Until after the dissolution, the Ohio Oil Company and the Prairie Oil and Gas Company also operated a system of pipe lines for the transportation of petroleum. It will be recalled that in 1914 the Illinois Pipe Line Company was incorporated to take over the main portion of the pipe-line system of the Ohio Oil Company, and in 1915 the Prairie Pipe Line Company was incorporated to take over the pipe-line business of the Prairie Oil and Gas Company.

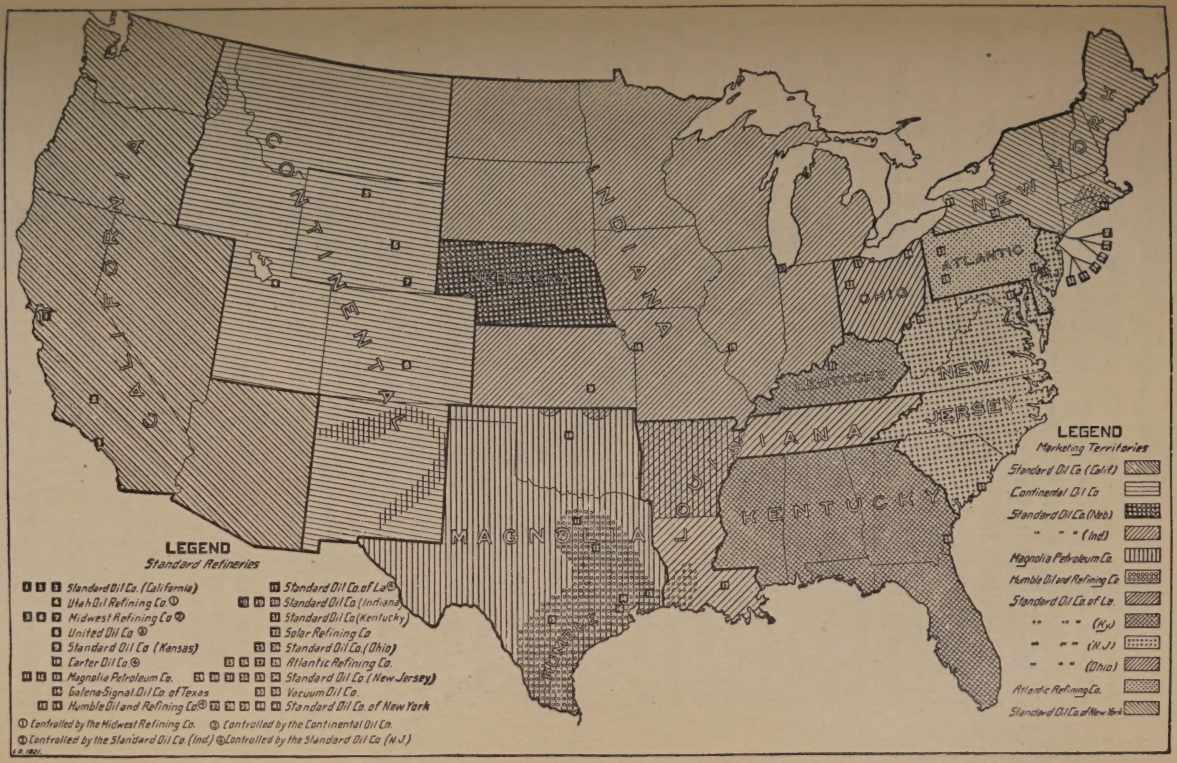
[2] The business of the remaining Standard Oil companies not specified above, but coming under the dissolution decree of 1911, was divided as follows: The Buckeye Pipe Line Company, the Crescent Pipe Line Company, the Cumberland Pipe Line Company, the Eureka Pipe Line Company, the Indiana Pipe Line Company, the National Transit Company, the Northern Pipe Line Company, the New York Transit Company, the Southern Pipe Line Company, and the Southwest Pennsylvania Pipe Line Company all engaged exclusively in the transportation of petroleum. (The lines of these companies together with those of the Ohio Oil Company and the Prairie Oil and Gas Company formed a comprehensive transportation system whereby the pools of the Mid-Continent field, the Lima-Indiana field, the Illinois field, and the Appalachian field were connected with the chief refining centers of the country.) The Atlantic Refining Company, the Standard Oil Company of Indiana, the Standard Oil Company of Kentucky, the Standard Oil Company of Ohio, the Standard Oil Company of New York, and the Waters-Pierce Oil Company engaged in both the refining and marketing of petroleum products. The Solar Refining Company and the Standard Oil Company of Kansas engaged exclusively in a general refining business. The Chesebrough Manufacturing Company manu-

cialized companies there was a marked degree of interdependence. In the main the products passed directly from one Standard company at a lower stage in the vertical scale of the industry to a Standard company at a higher stage, so that from the production of crude petroleum until its various products were marketed, the Standard concerns functioned as a working unit. Thus, the crude petroleum produced or purchased by the production companies was transported through the Standard's extensive pipe-line system to the different Standard refineries. After processing, the refined products were transferred to a separate sales organization or to the sales branch of the refining company and were thereby distributed to the consumers.

The dissolution decentralized control, but it did not disturb immediately this balance of intercompany activities. The Standard companies which formerly engaged in the production and purchasing of crude petroleum continued these activities and disposed of their products to their already established market — the Standard refining companies. The oil was transported through the pipe lines of the various Standard companies which acted almost exclusively as carriers of crude petroleum for their affiliated Standard concerns. The Standard refineries marketed their products directly through their own sales organization or disposed of them to their former customers — the specialized Standard marketing companies.

factured chiefly medicinal and toilet articles from petroleum, its main product being vaseline. The Galena-Signal Oil Company, the Swan and Finch Company, and the Borne-Scrymser Company were engaged exclusively in the manufacture and marketing of lubricating oils and heavy greases. The Vacuum Oil Company engaged exclusively in the manufacture of illuminating oils and gasoline. The Continental Oil Company and the Standard Oil Company of Nebraska were engaged exclusively in the domestic marketing of petroleum products. The Anglo-American Oil Company was the exclusive marketing agency for the United Kingdom; the Colonial Oil Company was the exclusive marketing agency for petroleum products in South Africa and Australia. The Union Tank Line Company engaged exclusively in the leasing of tank cars. The Standard Oil Company of California engaged in all branches of the petroleum industry.

FIGURE I. GASOLINE MARKETING TERRITORIES AND REFINERIES OF THE STANDARD OIL COMPANIES IN THE UNITED STATES



(From Federal Trade Commission, *Pacific Coast Petroleum Industry*, Part II.)

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This working balance has been maintained in its essential nature throughout the greater portion of the period since the dissolution. The geographic areas in which the various Standard marketing units previously operated have likewise remained intact throughout most of this period. It will be recalled that under the administration of the Standard Oil Company of New Jersey the United States had been divided into eleven marketing districts in each of which a separate marketing organization operated. (See Figure 1.) Control of the eleven companies was centered in the parent organization at 26 Broadway, New York City, and here the broader policies regarding prices, marketing practice, etc., for all its constituents were decided. Under this centralized control, while prices tended toward uniformity throughout the entire country, with due allowance for the item of freight, they varied somewhat in different sections according to the effectiveness of competition. Those sections in which competition was especially strong were generally favored with lower prices than those sections in which the Standard's monopoly was more secure. These eleven marketing districts were not immediately disturbed by the dissolution decree. Each segregated Standard marketing unit has since confined its activities, for the most part, to the trade territory which it occupied at the time of the dissolution. Each separate Standard company has retained almost exclusive control of Standard refined products in the territory originally allotted to it. There has been little competition among the original Standard units.[1] (See Fig-

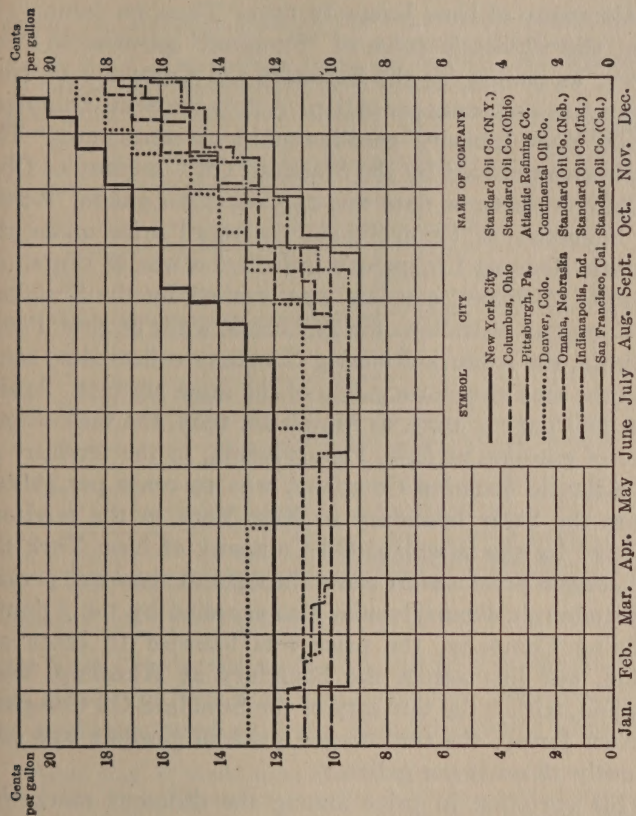
[1] In recent years two or more Standard companies in some instances sell in the same territory. For example, as shown on the map, the Magnolia Petroleum Company has service stations at certain points in New Mexico, which formerly was the exclusive territory of the Continental Oil Company; the Magnolia Company also sells in Arkansas, which is also a part of the territory of the Standard Oil Company of Louisiana. The Standard Oil Company of California and the Continental Oil Company have both sold gasoline in certain parts of Western Idaho. The Atlantic Refining Company has extended its sales into certain portions of Massachusetts, Rhode Island, and Connecticut; territory formerly served exclusively by the Standard Oil Company of New

ure 1.) Some of them engage in both the refining and marketing business; others in marketing only, in which case they have continued, in large part, to purchase their products from Standard refineries; but in either case, each company operates independently in its own marketing territory. The marketing areas are distinct and, with the exceptions noted, do not overlap. They are arbitrarily bounded, following in the main political rather than economic boundary lines. The Standard Oil Company of New York exactly comprises the New England States and New York, but no others. The Standard Oil Company of Ohio does business only in Ohio. The Standard Oil Company of Indiana embraces a compact group of ten North Central States with a small territory in Oklahoma. And so it goes. Instead of price policies now being determined at 26 Broadway for the entire eleven districts jointly, each concern apparently decides these matters independently. The result has been a curious variation in prices seemingly out of proportion to differences of costs in the various areas.

Figure II shows the details of this variation in the tank-wagon price of gasoline in 1915 among seven cities in as many different Standard marketing territories. It will be noted that on January 1, the price of gasoline varied from 10 cents per gallon at Pittsburgh in the territory of the Atlantic Refining Company to 13 cents at Denver, Colorado, in the territory of the Continental Oil Company. In July, the price varied from 9 cents at San Francisco in the territory of the Standard Oil Company of California to 13 cents at New York City in the territory of the Standard Oil Company of New York. In December these two cities still marked the extremes of price variation although the discrepancy at that time was much greater. The price in

York. Through its control of the Humble Oil and Refining Company, the Standard Oil Company of New Jersey has extended its marketing territory into the southeastern part of Texas and Southwestern Louisiana. *Pacific Coast Petroleum Industry, op. cit.*, part II, p. 129.

FIGURE II. RELATIVE MOVEMENT OF TANK-WAGON PRICES OF THE SEVERAL STANDARD OIL COMPANIES AT SPECIFIED POINTS IN THE UNITED STATES DURING 1915



(Data from Federal Trade Commission, *Report on the Price of Gasoline in 1915*, pp. 169, 170.)

San Francisco had advanced to 13 cents while the New York price had advanced to 21 cents.

The variation in prices in 1915 among the different Standard territories is typical of conditions that have prevailed continuously since the dissolution of the Standard Oil Company of New Jersey in 1911. Thus, on January 1, 1919, the wholesale price of 'Standard' gasoline in New Jersey, as posted by the Standard Oil Company of New Jersey, was 22.5 cents per gallon. Across the State boundary in New York, 'Socony' gasoline sold for 2 cents more.[1] The retail price received by the Standard Oil Company of Ohio in Ohio on the same date was 25.5 cents per gallon. Across the boundary in Pennsylvania the retail price under the Atlantic Refining Company's jurisdiction was 28 cents. At Detroit, Michigan, gasoline was retailed by the Standard Oil Company of Indiana for 23.7 cents, while at Erie, Pennsylvania, the Atlantic Refining Company collected 29 cents from the motorists for a gallon of the same product. Again, from February 9, 1925, to March 16, 1925, the tank-wagon price of gasoline at Erie, Pennsylvania, in the territory of the Atlantic Refining Company, was 19 cents per gallon; across the State boundary in New York in the territory supplied by the Standard Oil Company of New York the tank-wagon price was 21 cents throughout the same period; at Pittsburgh, Pennsylvania, also supplied by the Atlantic Refining Company, the price was likewise 19 cents per gallon, but just across the boundary at Wheeling, West Virginia, within the territory of the Standard Oil Company of New Jersey, the tank-wagon price of gasoline was consistently 18 cents per gallon.[2]

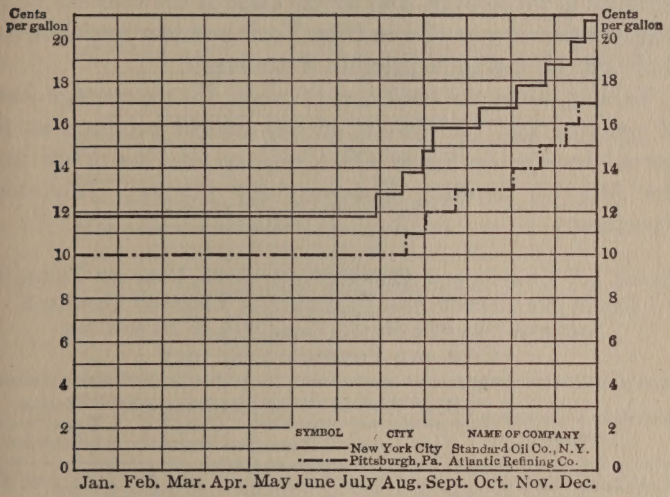
This variation in price among the different marketing areas is no doubt to be explained in part by differences in costs and by local conditions of supply and demand. The

[1] Maguire, A. G., Report of the United States Fuel Administration, *Prices and Marketing Practices Covering the Distribution of Gasoline and Kerosene throughout the United States*, pp. 7–11.

[2] These prices are exclusive of State gasoline taxes which show considerable variation.

variation, however, as judged by available evidence, appears to be out of all proportion to the influences of these factors.[1] Figure III shows the relative movement of tank-wagon prices of gasoline per gallon throughout 1915, after deductions have been made for freight charges as between

FIGURE III. RELATIVE MOVEMENT OF TANK-WAGON PRICES, AFTER DEDUCTION FOR FREIGHT, OF THE STANDARD OIL COMPANY OF NEW YORK AT NEW YORK CITY, AND THE ATLANTIC REFINING COMPANY AT PITTSBURGH, PENNSYLVANIA DURING 1915



(Data from Federal Trade Commission, *Report on Price of Gasoline in 1915*, p. 16.)

New York City in the marketing territory of the Standard Oil Company of New York, and Pittsburgh, Pennsylvania, in the marketing territory of the Atlantic Refining Company.[2]

[1] *Prima facie*, it would seem that in numerous instances the chief explanation for a discrepancy in prices as between two adjacent areas is the fact that they are under the jurisdiction of different Standard companies; and it should be noted in this regard that the marketing areas of these companies conform to political not economic boundary lines.

[2] This item of freight on the refined product in these instances is practically negligible. New York City was supplied from a Standard refinery in New York Harbor, and Pittsburgh was supplied by a Standard refinery at Pittsburgh.

It will be noted that throughout the first six months of the year there was a constant and sustained difference of almost two cents in the tank-wagon prices of gasoline in these two cities.

Shortly after the middle of the year, prices in both cities moved upward. This advance continued at intervals throughout the balance of the year. The advance in New York City, however, was somewhat more rapid than the advance in Pittsburgh, and by the close of the year the tank-wagon price of gasoline in New York was four cents higher than the tank-wagon price in Pittsburgh.

Table 3 shows the book cost of crude, the percentage yield of gasoline and the gravity of the refined product, as reported by the Standard Oil Company of New York and the Atlantic Refining Company for January, July, and December.

TABLE 3.* COMPARISON BETWEEN THE BOOK COST OF CRUDE IN CENTS PER GALLON, THE PERCENTAGE YIELD OF GASOLINE AND THE GRAVITY OF THE GASOLINE AT NEW YORK CITY AND PITTSBURGH IN 1915

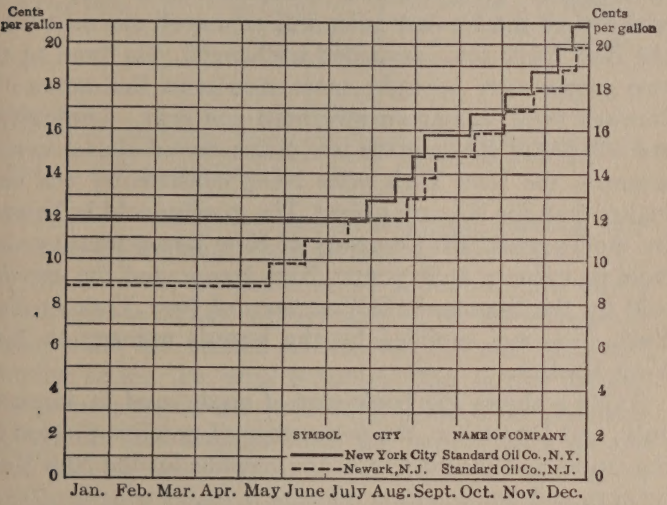
REFINERY FROM WHICH SUPPLIED	BOOK COST OF CRUDE			PERCENTAGE OF GASOLINE YIELDED	BAUMÉ GRAVITY OF GASOLINE
	Jan.	July	Dec.		
New York Harbor..	3.24	3.00	4.81	22.7 †	62.4–62.8
Pittsburgh.....	3.90 ‡	3.55 ‡	4.44	21.3	63 –65

* Data from Federal Trade Commission, *Price of Gasoline in 1915*, pp. 169-70.
† Yield at Atlas Works, New York.
‡ Not reported separately at Pittsburgh refinery.

It will be noted that there is little difference in the book cost of crude as between the two refineries supplying the gasoline. The Pittsburgh cost is a little in excess of the New York cost in January and July, while the New York cost is slightly in excess of the Pittsburgh cost in December. Likewise, there is little difference in the percentage of gasoline yielded by the two crudes and in the gravity of the gasoline. The Pittsburgh refinery apparently secured a slightly less volume of gasoline from each barrel of crude

than did the New York refinery, and the gasoline was of a slightly higher grade. We should expect the price of gasoline, therefore, to the extent that it was influenced by these factors — cost of crude, yield of refined gasoline, and quality of gasoline — to be slightly higher on the average

FIGURE IV. RELATIVE MOVEMENT OF TANK-WAGON PRICES, AFTER DEDUCTION FOR FREIGHT, OF THE STANDARD OIL COMPANY OF NEW YORK AT NEW YORK CITY, AND THE STANDARD OIL COMPANY OF NEW JERSEY AT NEWARK, NEW JERSEY, DURING 1915



(Data from Federal Trade Commission, *Report on the Price of Gasoline in 1915*, pp. 169, 171.)

in Pittsburgh than in New York City. On the contrary, the market price of gasoline at New York City was markedly and persistently higher than the market price of gasoline in Pittsburgh throughout the whole of 1915.[1]

Figure IV shows the relative tank-wagon prices of gasoline per gallon in 1915, after deductions have been

[1] Cost of marketing as reported by the two companies showed no consistent difference, although it varied considerably throughout the year. In January, the costs per gallon were almost identical; in July, the Pittsburgh cost was somewhat less than the New York cost; and in December, the Pittsburgh cost exceeded the New York cost.

made for freight, at Newark, New Jersey, in the marketing territory of the Standard Oil Company of New Jersey, and in New York City just across the State boundary line, in the marketing territory of the Standard Oil Company of New York. It will be noted that the price of gasoline in New York City is persistently higher than the price of gasoline in Newark. The year opened with gasoline selling for three cents higher at wholesale in New York City than in Newark. This situation continued until May 19, at which time the Newark price was advanced one cent while the New York price remained unchanged. On June 14 the two prices were brought more nearly in line when the Newark price was again advanced one cent. Throughout the balance of the year the two prices moved almost in consonance, the New York price being consistently one cent higher than the Newark price.[1] The gasoline sold in Newark by the Standard Oil Company of New Jersey was supplied from its refinery at Bayonne, New Jersey, and the gasoline sold by the Standard Oil Company of New York in New York City was supplied by the latter's refinery on New York Harbor.

Table 4 shows the book cost of crude used in January, July, and December, the percentage of gasoline yielded by the crude, and the gravity of the gasoline for the New York refinery and the Bayonne refinery.

It will be noted that for January and July the book cost of crude as reported by the Bayonne refinery was slightly higher than the book cost of crude as reported by the New York refinery, while the book cost of crude for December was slightly higher at the New York refinery. The New York refinery consistently obtained a larger volume of gasoline from the crude refined. The gasoline at each refinery was of substantially the same grade. The price of gasoline as influenced by these factors, cost of

[1] This difference may be due in part to a difference in methods of marketing. Gasoline in New York City is delivered in steel barrels, while in Newark it is delivered by tank wagon.

crude, and the recovery of gasoline, should have been slightly higher at the Bayonne refinery than at the New York refinery during January and July, and perhaps also

TABLE 4.* COMPARISON BETWEEN THE BOOK COST OF CRUDE IN CENTS PER GALLON, THE PERCENTAGE YIELD OF GASOLINE AND THE GRAVITY OF THE GASOLINE AT NEW YORK CITY AND NEWARK

REFINERY FROM WHICH SUPPLIED	BOOK COST OF CRUDE			PERCENTAGE OF GASOLINE YIELDED	BAUMÉ GRAVITY OF GASOLINE
	Jan.	July	Dec.		
New York Harbor..	3.24	3.00	4.81	22.7 †	62.4–62.8
Bayonne, N.J.....	3.90	3.62	4.50	17.6	61 –62.6

* Data from Federal Trade Commission, *Price of Gasoline in 1915*, pp. 169–70.
† Yield at Atlas Works, New York.

for December. On the contrary, however, gasoline consistently sold for less at Newark than at New York City.

On the basis of available data [1] it seems that widely fluctuating costs do not entirely account for the wide range of prices that has existed among the different Standard marketing areas. To what influence then is this marked sectional variation in the price of gasoline to be ascribed? It apparently has resulted from the maintenance on the part of the segregated units of the original Standard Oil Company of New Jersey of the artificial boundaries between the trading territory of each. It has grown out of the fact that the separate units have not competed, but have limited their activities in the main to the territory in which they were operating at the time of the decree in 1911. The situation in this respect has not changed greatly since the decree. But there is lacking a uniformity of policy which prevailed under centralized control. Since the dissolution, the various Standard companies, in establishing their prices and marketing practices, have been individualistic in the extreme.

[1] For a comprehensive discussion of the variations in the price of gasoline among the different Standard organizations and data pertaining thereto, see *Price of Gasoline in 1915*, *op. cit.*, *passim*.

Legal restraint has apparently contributed materially to this situation. Within the different marketing areas the prices established apparently represent the varying conceptions of the operating administrations as to what the traffic in petroleum products will bear.

The maintenance of separate marketing areas divided by definite geographic boundary lines represents an artificial interference with the forces of supply and demand. These forces, if allowed to function in a free and unrestrained fashion, would in the long run tend to establish an equilibrium of values between the different sections, which would take account only of temporary differences in local demand and the more permanent factor of variating costs of production. Competition between the separate Standard units, while it would tend to establish such an equilibrium of values, is of course not a prerequisite to this end. This result would be accomplished in an equally effective manner were there genuine and unrestricted competition between the independent companies and the Standard company within the various marketing areas.

Ostensibly, such competition does exist within each of the Standard marketing areas. It will be recalled that a large volume of capital has flowed into the industry since the dissolution decree, and that to-day the Standard interests in the aggregate control a smaller percentage of the total traffic in petroleum and its products than the Standard Oil Company of New Jersey did during the decade prior to its dissolution. The competitors of the several Standard companies differ widely in power, and their trade activities are unequally distributed throughout the country. A considerable portion of the independent capital in the industry to-day is represented by the investment of several large concerns which engage in all branches of the industry and carry on a marketing traffic in petroleum products Nation-wide in its scope. For example, the Texas Company in 1922, with storage stations for refined products in forty different States, did a marketing business in every section

of the country.[1] The Sinclair Consolidated Oil Corporation likewise maintained distributing stations for its manufactured products in twenty different States, and did a marketing business in almost every section of the country.[2] The Pure Oil Company maintained distributing stations and did a retail marketing business in sixteen states.[3] Numerous other concerns do a similarly scattered though less extensive business. As contrasted with these larger concerns which do a marketing business in competition with the various Standard units over a wide territory, there have grown up in the oil-field regions a large number of relatively small refineries which depend upon local supplies of crude oil and to a great extent upon independent jobbers for the marketing of their products. Concerns of this type are especially abundant in the Middle-Western States near the oil fields of the Mid-Continent territory. These smaller refineries and the jobbers dependent upon them have become in recent years active competitors of the various Standard companies, their competition being especially important in the territory embraced by the Standard Oil Company of Indiana and the Magnolia Petroleum Company. Thus, in all sections of the United States the various Standard units meet competition from independent concerns.

It will be recalled that these independent companies to-day market about half the total volume of refined products consumed in this country. Despite the growing importance of this group of independent companies, however, the controlling factor in determining the price of gasoline and other petroleum products seems to have been the dominating influence of the various Standard companies, each in the territory in which it has operated. In each territory the Standard Company is so much larger than any single competitor that the price of refined products as posted by the Standard Company has been the accepted

[1] Hearings, *op. cit.*, part III, p. 877.
[2] General Service Corporation, *Independent Oil Stocks*, 1922, p. 124.
[3] *Ibid.*, p. 100.

market price to which independent companies have adhered. Such competition as has existed has been largely a competition of service, of prestige through advertising particular products, rather than a competition of prices. Occasionally prices charged by independents have varied for a short time from the prices charged by the different Standard companies and 'price wars' of short duration have occurred sporadically throughout the country during the last decade; but in the main, the Standard group has determined the prices of petroleum products.[1] Independents have generally accepted the Standard prices and have varied their prices with the Standard changes.[2] The Federal Trade Commission described the situation in 1915 in the following words:[3]

> The various Standard companies, with relatively unimportant exceptions, in announcing their tank-wagon price of gasoline in any locality, practically fix the price that prevails. As a rule, and throughout most of the country, the prices announced by Standard concerns as the ones at which they will sell their products are carefully watched and followed more or less closely by the so-called independents.

By 1919 the situation seems not to have changed. At this time the United States Fuel Administration had the following to say: 'They (the independents) usually adopt the prevailing prices and marketing practices of the Standard Company. Thus each Standard company in establishing values and practices sets the pace for all.'[4] Again in 1920

[1] During the recent period of overproduction with the appearance of so-called 'bootleg' crude and 'distress' gasoline (see note 2, page 88) price cutting has become a more common practice. Throughout Ohio, the marketing territory of the Standard Oil Company of Ohio, at the opening of 1925, price cutting had apparently become quite general. See *National Petroleum News*, January 7, 1925, p. 20.

[2] This statement applies only to the price of kerosene and gasoline. Fuel oil, largely a surplus product, has been marketed under highly competitive conditions. In the sale of lubricants the service factor is important and prestige plays a more important rôle than price.

[3] *The Price of Gasoline in 1915*, *op. cit.*, pp. 5–6.

[4] Maguire, A. G., *op. cit.*, p. 13.

the statement is reiterated by the Federal Trade Commission in the following language: 'Price initiative to-day seems to be left generally to the Standard companies and competition is apparently more directed to developing facilities for getting business than to seeking to obtain it by underselling.' [1] The recent hearing before the sub-committee of the Senate Committee on Manufactures indicates that the dominating control of the Standard companies in matters of price remained unshaken at the close of 1922. In commenting upon the situation as set forth by the testimony of representatives of the leading independent companies, the Senate Committee had the following to say: 'The controlling factor in fixing the retail price of gasoline and other petroleum products is the dominance by the Standard Oil companies of the retail market for those products throughout the United States, and particularly of gasoline and kerosene.' [2]

Despite the consensus of opinion regarding the domination of the industry by the Standard Company on the part of the governmental agencies which have looked into the matter, representatives of the Standard interests contend that prices of petroleum products are the resultant of unrestrained competitive forces. The Standard Oil Company of New Jersey, through its house organ, *The Lamp*, has the following to say in defense of this position:[3]

> The crux of the gasoline situation is this: The price is not fixed by Standard Oil Company (N.J.) or by any other large company nor by any association or group of companies. It is fixed by the consumer and expressed by demand. Last fall many refineries found themselves embarrassed by large stocks and with insufficient working capital to carry these over until business might resume. There

[1] Federal Trade Commission, *The Advance in the Price of Petroleum Products*, 1920, p. 53.

[2] Committee on Manufactures, *op. cit.*, p. 41. *See also*, the testimony of Mr. A. L. Beaty, president of the Texas Company, Hearings, *op. cit.*, p. 883, and Mr. G. B. Dawes, president of the Pure Oil Company, *ibid.*, p. 1046.

[3] *The Lamp*, vol. v, No. 1, p. 4.

ensued a drive for business at prices made regardless of cost. The Oklahoma gasoline market, jobber's price, went to twelve cents a gallon, and in doing so established the base price for gasoline the country over. It mattered not what it was costing refiners either in Oklahoma or on the Atlantic seaboard to produce gasoline; the market was fixed by the refiners' necessity.

With their surplus stocks largely converted into money, the seasonal demand for gasoline was again experienced with the approach of the summer of 1922. In the space of a few weeks the same people who had established the price of twelve cents put it up to nineteen cents in Oklahoma, or the equivalent of about twenty-five cents at the Atlantic seaboard, taking in freight charges. This was the reflection of the working of the simplest economic law, uninfluenced by any of the considerations raised in the Senate's questionnaire. The article in question might just as well have been strawberries or cotton. When more of a product is offered than the public will consume, the price falls in the effort of each producer to move his stock. When the demand reappears he follows it up with an advance in prices in an effort to recoup his losses.

Is this explanation by the Standard a convincing answer to the above charges as to its complete domination of the industry, or does the truth lie somewhere between?

CHAPTER VI

THE STANDARD'S POSITION IN THE INDUSTRY TO-DAY

Obviously, there is much of practical common sense and good economic theory in what the Standard has to say in regard to the operation of the forces of supply and demand. Ultimately, of course, gasoline prices are determined by the operation of these forces, marginal utility or vendibility of the available supply in the last analysis accounting for the prices which may be charged on the basis of the 'price-paying disposition' of a gasoline-consuming public. But the Standard is the concern through which price changes are worked out, the barometer, as it were, which registers changes in the 'price-paying disposition,' fluctuations in the 'social marginal utility' of the commodity in question.

It should also be noted that these fluctuations over short periods of time are not very great. It would seem that the demand for gasoline is relatively inelastic, the amount purchased varying but slightly with changes in its price. Particularly is this true in so far as the product is used for commercial purposes. The amount of gasoline consumed by the professional man, by the delivery department of the mercantile establishment, by the commercial taxi-cab, or by the auto truck and moving van, will tend to vary only slightly with changes in the price of gasoline. The demand for gasoline is a derivative demand, arising from a demand for motor transportation. Motor transportation involves the utilization of a motor vehicle with the necessary appurtenances. In the operation of a motor car, the cost of gasoline constitutes only a small percentage of the total expenses. A commercial automobile may involve an original investment of several thousand dollars. In the operation of such a car, the fixed charges make up a large

proportion of total costs. Depreciation charges, interest on investment, storage charges, insurance, taxes,[1] drivers' salaries — these expenses remain constant whether the machine is run little or much.[2] With the cost for gasoline constituting but a relatively small percentage of total costs, a large portion of which are of a fixed nature, the business man will be little influenced in his purchase of gasoline by changes in its price. The same reasoning applies, though perhaps with less force, to the pleasure car. The average gasoline consumption for each motor car in the United States in 1922 was roughly four hundred and twenty gallons. A variation of ten cents per gallon in the price of gasoline (which, of course, would be a very extreme one) would mean a change in the average gasoline bill per automobile of about forty-two dollars over a period of a year. To the motorist who has invested several hundred, or perhaps several thousand, dollars in a pleasure car, an increase of a few cents in the price of gasoline is not apt to serve as an effective deterrent in the use of his car for purely pleasure purposes. Likewise, a decrease of a few cents in the price of gasoline is not apt to increase to any marked degree the amount of gasoline consumed.[3]

But while a few cents' variation either upward or downward may not affect to any marked degree the amount of

[1] A gasoline tax based on gallonage consumed is, of course, a variable expense.

[2] According to Dr. Edwin E. Slosson, the best estimate for total expenditure for motor cars in this country during 1921 is $6,335,000,000, exclusive of the investment in new cars. This expenditure was distributed as follows: Depreciation, $1,800,000,000; interest, $295,000,000; tires, $450,000,000; gasoline, $823,000,000; oil, $175,000,000; garage, $552,000,000; repairs and supplies, $1,000,000,000; insurance, $185,000,000; taxes, $275,000,000; drivers' salaries, $600,000,000; and road maintenance, $180,000,000. See *Science Remaking the World*, edited by Otis W. Caldwell and Edwin E. Slosson (New York, 1923), p. 30.

[3] In the long run, of course, the price of gasoline exerts an influence on the sale of automobiles, and hence an influence on the consumption of gasoline. But in the purchase of a car, the initial investment, coupled with the general expense of operation, of which gasoline makes up only a small part, would seem to be the deciding factor.

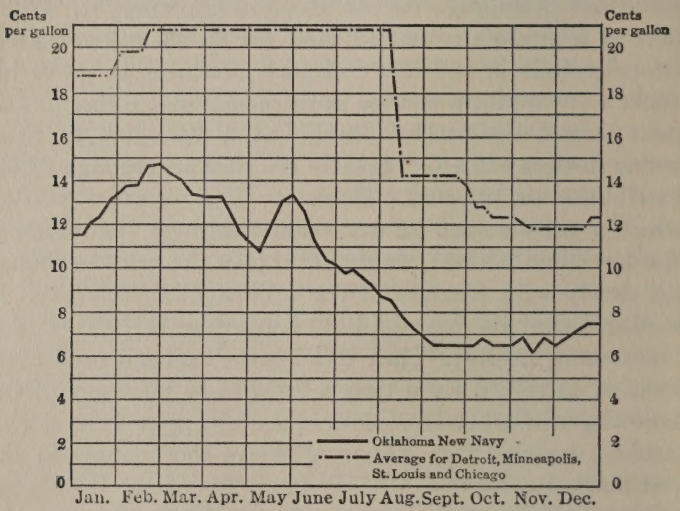
gasoline consumed, it will affect very greatly the profits of the dealer. Thus an increase of only one cent in the average price for gasoline sold during 1922 would have increased profits from the sale of gasoline by more than $53,000,000. Since the demand for gasoline is relatively inelastic, under genuinely competitive conditions, we should expect the price of gasoline to adjust itself readily and promptly to conditions of supply. As Mr. Bedford expressed it, 'When more of a product is offered than the public will consume, the price falls in the effort of each producer to move his stock.' [1] A uniform change in price may not affect to any great extent the amount sold, but a variation in price among dealers will affect greatly the channel through which distribution is effected. However, if a uniform market price for gasoline can be maintained through the influence of a dominant interest, we should expect the price to change but slowly with changes in the total available supply. It is alleged that the Standard Oil companies constitute such a dominant interest. That this power has been used upon occasion to retard for a time a downward tendency of the tank-wagon market is evidenced by the price behavior of gasoline during 1923. Figure V shows the changes in the spot market price of New Navy gasoline at the Oklahoma refineries during the year 1923 and the changes in the average wholesale price of gasoline for four cities in the territory of the Standard Oil Company of Indiana.

It will be observed on the map that this territory embraces all of ten States and a portion of an eleventh State in the Middle-Western section of the country. A portion of two of these States is in the heart of the Mid-Continent oil

[1] In the long run the price of gasoline is influenced by cost of production subject to the principle of joint cost, gasoline being a joint product with kerosene, fuel oil, and other refined products. Hence the competitive price at which gasoline would sell would be influenced by the demand for the other products jointly produced with it. In the discussion that follows, we will disregard long-time factors and confine our attention to the immediate response between changes in the jobber's price of gasoline and the wholesale tank-wagon price.

fields and nearly all of the States have excellent railway connections with the oil-field regions. In much of this territory, which is in close proximity to the base of refined supplies, we should expect competition to be especially active.

FIGURE V. COMPARISON BETWEEN THE OKLAHOMA F.O.B. REFINERY PRICE OF NEW NAVY GASOLINE AND THE AVERAGE TANK-WAGON PRICE OF FOUR CITIES IN THE TERRITORY OF THE STANDARD OIL COMPANY OF INDIANA DURING 1923



Indeed, it is in this general section that the strength of independents is reputed to be greatest. We should, therefore, expect the wholesale tank-wagon price of gasoline to vary closely with the Oklahoma f.o.b. refinery price. It will be observed, however, that there is a marked divergence between these prices throughout a considerable portion of the year.

It will be noted that the trend of tank-wagon prices for the first eight months of the year is upward, there having been two price increases in the early months of the year, and no other changes from February 26 until about the middle of August. On the other hand, the trend of refinery prices is markedly downward throughout the entire year

and, with the exception of the temporary rise during the early part of the summer, the decline is uninterrupted from the first of March until the early part of October. The result of this anomalous behavior was a growing discrepancy between the Oklahoma refinery price and the Standard of Indiana's tank-wagon price. The average margin between these two prices increased from 6.1 cents for the four weeks' period from February 26 to March 25, inclusive, to 11.8 cents for the four weeks' period from July 17 to August 13, inclusive. On August 14, the Standard Oil Company made a general cut in its tank-wagon price of 6.6 cents per gallon throughout almost its entire territory.[1] This tremendous cut apparently did not represent a change in judgment on the part of Standard officials as to what the traffic would bear, nor did it result from the pressure of competition from independent oil companies. The move seems to have been in response to pressure from outside the industry. It seems that in approving bills for gasoline bought by the State Highway Department, Governor W. H. McMaster, of South Dakota, became impressed with the extremely wide margin between the refinery's spot market price for gasoline and the prevailing tank-wagon price.[2] Determined to establish a more equitable relationship between these, the Governor issued a proclamation on August 7, denouncing the tank-wagon price as unreasonably high and announcing to the public the sale of gasoline from the State warehouses at Mitchell at sixteen cents per gallon. This was a cut of 10.6 cents per gallon under the retail service-station price at that point. The Standard of Indiana responded to this move with a reduction of 8.6 cents per gallon in its tank-wagon price and 10.6 cents in its service-station price, effective throughout the State of South Dakota. Immediately the officials of the Standard of Indiana are said to have been besieged by requests for a similar reduction from the executives of other Western States who threatened to

[1] The cut in the State of Indiana was only 5.6 cents per gallon.
[2] See *National Petroleum News*, August 15, 1923, pp. 17–21.

follow the example of the Governor of South Dakota and establish retail gasoline dépôts were these requests not granted.[1] The Standard met these requests with price reductions general throughout its entire territory.[2]

It seems certain that the tank-wagon price as maintained by the Standard Oil Company of Indiana for several months prior to this decline was markedly higher than a genuinely competitive market would have made possible.[3] This opinion is borne out by the testimony of some of the leading representatives of the independent oil interests. During the spring and summer of 1923 the financial position of the independent refineries seemed precarious. Refinery stocks showed a continuous increase from the first of September, 1922, until the first of June, 1923. Refinery prices had responded promptly to increasing supplies and had shown an almost uninterrupted decline during this period.[4] The decline in the price of Mid-Continent crude oil as posted by the Prairie Oil and Gas Company was less marked and less consistent.[5] The refiners, forced to pay a

[1] See *National Petroleum News, loc. cit.*

[2] Economic forces were undoubtedly at work to bring about a general decline in the tank-wagon and retail price level. Perhaps the Standard had resisted these forces about as long as would have been possible had the Governor of South Dakota not precipitated matters. What is known in the trade as 'bootleg' crude oil, i.e., oil sold at less than the market price, and 'distress gasoline' were pushing their way into the market through other than the established channels of trade. The large profits in the jobbing trade had tempted numerous competitors into business and a break in the market seemed imminent.

[3] It does not appear, however, that had the price been lowered at an earlier date there would have been any marked increase in the consumption of gasoline. As the summer motoring season approached, the consumption of gasoline had shown a steady increase. Peak of consumption for the calendar year was reached at about the time these marked price changes were effected, but as the summer season closed the usual seasonal decline in gasoline sales began despite the lowered price level.

[4] From June 26, 1922, until June 25, 1923, the Oklahoma refinery price had declined from 19 cents to 10 cents, a decline of almost 50 per cent.

[5] During the summer of 1922 the price of crude oil had dropped rather abruptly from $2.00 to $1.25 per barrel. In November, 1922, the Prairie changed its method of posting prices. It no longer posted

relatively high price for crude, found difficulty in selling their refined stocks at prices sufficient to cover the cost of production. Despite declining refinery prices, the retail price of gasoline, which is based upon the tank-wagon price, had remained unchanged for several months throughout the entire territory served by the Standard Oil Company of Indiana. Independent jobbers, many of whom had purchased a part of their gasoline on marginal contracts, in an effort to relieve the situation of the refiners, endeavored to secure a readjustment between the price of crude oil, the price of gasoline at the refinery, and the tank-wagon and retail price of gasoline. As a means of accomplishing this object, an open meeting was held at Chicago on July 26, 1923, under the auspices of the National Petroleum Marketers' Association. At this meeting the jobbers voiced their almost unanimous opposition to existing wide margins between the tank-car price of gasoline at the refinery and the tank-wagon price to the retailer. Mr. L. V. Nicholas, president of the Marketers' Association, had the following to say in regard to the existing prices:[1]

> Now this is the thing we have to face. . . . We are the men who represent you to the consuming public. And staring us in the face, and staring the public in the face, is a 9-cent price for gasoline to us plus freight which does not average over 2.6 cents, and a tank-wagon price which represents 100 per cent profit, so as the public sees it.
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> . . . . . .

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a uniform price for all grades of crude, but varied the price according to the specific gravity of the crude. Under this new arrangement the price posted for crude oil of 33° to 34.9° gravity, Baumé scale, remained at $1.25. With the opening of 1923 there were six successive increases in the Prairie posted price for each of the various grades of crude oil. Oil of 33° to 34.9° gravity increased by successive ten-cent advances from $1.25 on January 15, to $1.85 on February 19. On April 23 the price was lowered ten cents. The price was again lowered on May 7 and it was further reduced by ten cents to $1.45 on May 14. It remained at this price until September 24 when it was reduced to $1.30. On November 12 the price was further reduced to $1.00. Independent refineries throughout this period generally paid a premium over the Standard's posted prices.

[1] *National Petroleum News*, August 1, 1923, pp. 17 *et seq.*

The refinery market price is a direct reflection of the law of supply and demand. The producer is already up against 'bootleg crude' which is a reaction to the law of supply and demand. But the posted price of crude to-day is the most abnormal, artificial thing that ever existed in relation to that law. And the thing we want to get over to the public is a logical explanation for a thing which looks like the rawest case of strong-arm tactics ever used to finance a situation.

. . . . . .

. . . I believe the time has come when the industry does not have to be at the mercy of the Standard Oil Company at every advance or decline. We have come to the point to-day when collectively we can play our own cards on the table face up, and that is what we have to do.

. . . We believe we have nothing to fear by going down with the law of supply and demand or coming up with it. If our desire for an advance is justified by economic conditions, we believe the time is past when the Standard Oil Company can fly in the face of those laws and 'get by' with it.

L. F. Kuehnle, of the Leader Oil Company, Dubuque, Iowa, further expressed the attitude of the jobbers with the remark that 'This oil jobbing business is no longer a business; it is a "hold-up."'

Whether or not this frank confession on the part of the jobbers that the margin between the tank-car price of gasoline to jobbers and the tank-wagon price to the retailer was entirely unjustified on the basis of economic factors, and their vigorous declaration of independence would have ultimately led them to lower the tank-wagon price, regardless of the course pursued by the Standard, is a matter of conjecture. The situation was not relieved, however, until Governor McMaster opened the South Dakota State warehouse for the distribution of gasoline to the public. And whether or not the independent companies would have carried into execution their threat to lower the market, the fact that they had not done so at an earlier date in view of the continued decline in refinery prices, is indicative of the dominating influence of the Standard Oil Company of Indiana throughout its territory.

The effectiveness of the Standard's domination of the industry and the means by which it has been maintained have apparently varied somewhat in different sections of the country. In certain sections the Standard has dominated the situation by means of its almost complete control through ownership of the industry in all its branches; in certain other sections a mutual understanding seems to have been effected between the Standard and the larger independents whereby the latter have agreed to accept the prices as posted by the Standard as the established market prices; and in still other sections the Standard's prices have apparently been accepted by the independents either because of a recognition on the part of independents of the good business practice of accepting prices as established by a so-called 'market-leader' or, in the case of smaller independents, because of fear of the Standard's power.

The Rocky Mountain oil-field region and the marketing territory of the Continental Oil Company, one of the original Standard group, afford illustrations of the Standard's complete domination through ownership and control. The Continental Oil Company is primarily a marketing company operating in the Rocky Mountain region. The bulk of its products is purchased from the Midwest Refining Company. It will be recalled that in 1920 and 1921 the Standard Oil Company of Indiana acquired control of the Midwest Refining Company through exchange of stock. This transfer gave the Standard interests practically complete control of the producing, transporting, refining, and marketing branches of the petroleum business throughout the entire Rocky Mountain section. The effects of this control are set forth in a recent report of the Federal Trade Commission.[1] The prices of gasoline in Montana and adjoining States were considerably higher in 1921 than in States nearer the Mid-Continent oil field. During the same period the prices of high-grade crude petroleum were

[1] Federal Trade Commission, *Petroleum Trade in Wyoming and Montana*, July, 1922.

much lower in Montana and Wyoming than in other States, yet the f.o.b. refinery prices of gasoline and kerosene of the Midwest Refining Company were much higher than the f.o.b. price at Mid-Continent refineries. At the time of the report, July, 1922, the Midwest Refining Company and the Ohio Oil Company, both Standard controlled, fixed the price paid to the producer at about sixty cents per barrel less than the price of similar quality Mid-Continent crude, while in the sale of gasoline, f.o.b. refinery, the Midwest charged a higher price for sales in Montana and a lower price for shipments destined for territories where it must meet greater competition from Mid-Continent refineries. In the purchase of crude and in the sale of gasoline, Standard interests took advantage of the cost of rail transportation to and from that section, the result being a relatively low price paid to the producer of crude and a relatively high price extracted from the consumer of gasoline.

It may be that no logical objection can be offered to such a policy on business grounds, but obviously any claim that such a practice results from the free working of competitive influences is fictitious and untrue. That the Standard interests in the Rocky Mountain region have been able to exact a relatively high price for their refined products, and at the same time pay a relatively low price for the crude product, follows directly from the Standard's monopoly control through ownership of every branch of the industry in this section. It should be noted that the production of refined products by the Midwest Refining Company has in general been considerably in excess of local needs. This excess during the period under review was largely disposed of to Standard marketing companies in other territories. A portion of the excess went to the Standard Oil Company of New York and was marketed in the State of New York. Transportation charges were met for roughly two thousand miles, and yet the New York retail price of gasoline was consistently several cents less than the prevailing price in the territory immediately contiguous to the Midwest re-

fineries. This testifies further to the complete monopoly which the Standard interests have enjoyed in the Rocky Mountain region.

The Standard's domination of the market in the Pacific Coast region seems to have been maintained in recent years by a mutual understanding between the Standard Oil Company of California and the more important independents operating in that region, whereby the prices of refined products as fixed by the Standard are accepted by the industry at large. The facts in this regard are set forth by the Federal Trade Commission in its recent *Report on the Pacific Coast Petroleum Industry*. During 1913, 1914, and the first half of 1915 a price war occurred in the marketing area of the Standard Oil Company of California. This situation developed during a period of flush production of crude petroleum accompanied by the construction of a number of new refineries. In the last quarter of 1914 the Standard Oil Company began the practice of selling gasoline direct to the consumer. At this time, and during the years since, the Pacific Coast petroleum industry has been chiefly in the hands of five large concerns: the Standard Oil Company of California, the Associated Oil Company, the General Petroleum Corporation, the Union Oil Company, and the Shell Company of California. The sales of these independents, with the exception of the General Petroleum Corporation, were made largely direct to the consumers. During the period from 1914 to 1919 the Standard Oil Company sold a larger quantity of refined products than any other single concern. The Standard marketed 60 per cent of the total gasoline sold by these five larger concerns. The Standard and Union together sold almost 83 per cent of the gasoline marketed by this group.[1] In 1919 the five concerns together marketed 93.5 per cent of domestic gasoline. On October 22, 1914, the Standard announced a reduction in the retail price of gasoline from 13.5 cents to 12.5 cents per gallon in the vicinities of Los Angeles and San Francisco.

[1] *Pacific Coast Petroleum Industry, op. cit.*, part II, p. 5.

The small refineries, fearing a price war that would drive them out of business, responded to this price change by forming an association on November 21, 1914, later incorporated as the Independent Petroleum Marketers' Association of California. Energetic efforts were made to secure the membership of the large marketing concerns. These efforts were not without success. The General Petroleum Company became a member in April, 1916; the Union Oil Company in September, 1916; and the Associated Oil Company in November, 1920. Since the organization of this association the prices for refined products as posted by the Standard Oil Company have been generally followed by the independents. In this connection the Federal Trade Commission has the following to say:[1]

> Memoranda of meetings and correspondence of the members of the Independent Petroleum Marketers' Association show that the Association members met frequently and discussed and agreed upon sales policies, the maintenance of price differentials, and the classification of customers. The market price was that named by the Standard Oil Company, which established and maintained fixed differentials for different classes of customers. The members of the Marketers' Association agreed to maintain and follow the retail price and the differentials allowed by the Standard for the different classes of customers.

In September, 1915, a rumor of an advance in the market was followed by a meeting of the association and a decision to adjust all differentials to precisely the same basis by the different concerns. Commenting on this move the Federal Trade Commission says:[2]

> The Standard's Los Angeles representative reported to the Standard's general sales manager that on September 23, 1915, 'We find that all companies have followed our price signs and several of the members of the Independent Petroleum Marketers' Association have telephoned me this morning to voice their approval of the advance and indicate to me they are going to show our company now that they intend to be fair competition' [competitors].

[1] *Pacific Coast Petroleum Industry, op. cit.*, part II, p. 7.
[2] *Idem.*

The uniformity of price policies on the part of ostensible competitors is indicated in the submission of bids for the refined oil supply for the city of Los Angeles for 1917. It was agreed at a meeting of the association that only the Standard and three independent concerns should submit bids, and these were to be '1 cent off open tank-wagon market price at time and place of delivery.'[1] Identical bids were submitted and rejected. New bids were called for. The same firms responded again with identical bids and again they were rejected.

During the period of 1914–1920 there were departures from time to time from the Standard's prices by small recalcitrant independents, but throughout the period 'changes in the market price of refined petroleum products were either made simultaneously or practically simultaneously by all of the large marketing companies, and the announced prices were always identical. The volume of sales of the Standard Oil Company for all petroleum products, except fuel oil, were so much larger than the quantity sold by any other company that the Standard was recognized even by the other large companies as the leader in the establishment of market prices.'[2] By 1920 the smaller concerns seem to have stepped into line. 'In the spring of 1920 there was complaint on the part of the small refiners because the price of the lighter grades of crude petroleum had been increased greatly while gasoline had only been advanced 2 cents per gallon, and there was very little complaint of price cutting.'[3]

Throughout other sections of the country the Standard's control of the market seems to have rested largely upon its strength as the most important company in the field. The larger independents apparently consider it a matter of good business policy to accept the prices as established by the Standard group. The smaller independents seem to have a genuine fear of the Standard's ability to force them out of business should a price-cutting campaign be inaugurated.

[1] *Pacific Coast Petroleum Industry*, *op. cit.*, part II, p. 8.
[2] *Ibid.*, p. 10. [3] *Ibid.*, p. 9.

Hence, they also find it expedient to accept the prices as established by the Standard units. President Nicholas of the National Petroleum Marketers' Association, testified in this regard before the sub-committee of the Committee on Manufactures on January 15, 1923, as follows: 'If you start real competition — and by that I do not mean multiplying the opportunities we have to-day to buy stuff, but I mean competition that bases its price on cheaper delivery cost — you are up against a system of reprisals that rather deprive you of a desire to try the experiment more than once.' [1] In general, independent jobbers seem to rely almost entirely upon the tank-wagon price as posted by the various Standard companies as the price at which they will dispose of their products, and in accordance with this practice a considerable portion of their purchases from independent refiners are made upon a marginal contract basis; i.e., they contract for their supplies from independent refiners at a price which bears a definite relationship to the posted price of one of the Standard companies. This contract price moves in consonance with the tank-wagon price of the Standard Company in the territory of which the gasoline is marketed.[2]

An important factor in the Standard's control of the oil industry prior to the dissolution decree of 1911 was its control of the major pipe lines of the country. Railways cannot compete effectively with pipe lines in the transportation of crude oil. With their comprehensive network of gathering and trunk pipe lines, through which the oil is forced by steam- or electrically- driven pumps, their extensive storage facilities, and their telegraph lines of communication by means of which oil is dispatched and guided, the pipe-line transportation systems of the country perform the mar-

[1] *Hearings, op. cit.*, p. 572.

[2] See *National Petroleum News* (July 4, 1923), p. 18. Since the fall of 1924 there has been considerable agitation among independent oil jobbers for a change in the form of contract and the method of basing prices. So far as the writer is aware, there has been no general departure from the practice outlined above.

keting functions of transportation, concentration, and storage at a far less cost and far more efficiently than is possible with tank cars and railway equipment.[1] Control of pipe lines, therefore, had given the original Standard Oil Company of New Jersey a tremendous advantage over its competitors. On the one hand, the Standard by reason of this control had been able to economically locate its refineries at or near marketing centers and thereby, through the elimination of freight rates on the refined products, had secured an important advantage over its smaller competitors; and on the other hand, through its refusal to transport any petroleum that had not been sold to it, it had been able to practically dictate the price which it paid for the crude product.[2]

Recognizing the important function which pipe lines perform and the advantage which their control carries with it, Congress, prior to the dissolution proceedings, by the enactment of the Hepburn Act in 1906, had declared pipe lines to be common carriers and as such under the jurisdiction of the Interstate Commerce Commission and subject to the provisions of the Interstate Commerce Act. Despite this legislation, the pipe lines of the country which were almost completely under the control of the Standard Oil Company, did not immediately function as common carriers; and up until the time of the dissolution decree they had remained largely nothing more than plant facilities transporting oil from the producing fields to affiliated refineries.[3]

[1] See Chapter XI.

[2] 'In this way it made itself master of the fields without the necessity of owning them and carried across half the continent a great subject of international commerce coming from many owners, but by the duress of which the Standard Oil Company was master, carrying it all as its own.' United States *vs.* Ohio Oil Company, *et al.* Opinion of the Court, 234 *United States Reports*, 559.

[3] Prior to June 22, 1914, no common-carrier shipments of crude petroleum had been made in interstate commerce. On that date the Supreme Court of the United States rendered a decision in the case of United States *vs.* Ohio Oil Company, *et al.* The Court held all pipe lines to be common carriers under the jurisdiction of, and subject to, regulations prescribed by the Interstate Commerce Commission, in

Since the dissolution decree it will be recalled that the Standard has lost in some measure its control of the pipe lines of the country. In 1919, however, it still controlled approximately 68 per cent of the total mileage. The balance of the mileage is largely under the control of a few large completely integrated concerns. The Standard Oil group, therefore, together with a few large independent companies, have almost complete control of the pipe-line transportation system of the country to-day.

While all of these pipe lines, which conduct an interstate traffic in crude petroleum, have been declared by Congress and the courts to be common carriers, no adequate measures have yet been taken to make them common carriers in fact. The companies controlling the pipe lines have so hedged about the pipe-line service as to make it practically unavailable for any except a few favored companies. Various devices have been utilized which have served to defeat the purpose of the Hepburn Act. For example, the Prairie Pipe Line Company and the Sinclair Pipe Line Company require a minimum shipment of 100,000 barrels and the Magnolia Petroleum Company will accept no shipment for less than 25,000 barrels.[1] Since it will take many small refineries at least six months to consume 100,000 barrels of crude oil, and since many producers would have to accumulate their crude oil for years before they obtained 100,000 barrels, it

accordance with the act to regulate commerce, as amended June 29, 1906. See 234 *United States Reports*, 548–75. See also Federal Trade Commission, *Report on Pipe-Line Transportation of Petroleum* (Washington, 1916), p. 3. Notwithstanding this decree, pipe-line companies doing an interstate pipe-line transportation business have not since generally operated as common carriers. *Cf. infra.*

[1] See *Report on Pipe-Line Transportation of Petroleum, op. cit.*, pp. 448–49. Also *Hearings, op. cit.*, part VI, pp. 1518–23.

By order of the Interstate Commerce Commission the Prairie Pipe Line Company, since July 16, 1922, has been required to accept shipments of not less than 10,000 barrels from points in Kansas, Oklahoma, and Texas to Franklin and Lacy Station, Pennsylvania. See Order of Interstate Commerce Commission, Case No. 11512, Brundred Brothers *vs.* Prairie Pipe Line Company, *et al.* Also *Hearings, op. cit.*, part VI, p. 1516.

is evident that such a large minimum-shipment requirement may alone prevent small companies from using pipe lines as common carriers.[1] Moreover, deliveries have been accepted, in general, only for certain 'established delivery stations' on the lines of the company transporting. These established delivery stations are generally the points at which affiliated refineries are located. Independent refineries located elsewhere, even though along the route of an interstate pipe line, have not been able to avail themselves of the transportation facilities. Thus, by one means or another, the pipe lines of the country which do an interstate traffic in petroleum, while common carriers by law, have remained in fact little more than 'plant facilities, bringing the oil from the producing fields into the Standard Oil Company refineries; and those of a few other large companies.'[2] It seems, therefore, that neither the Court's decree nor the legislation of Congress has yet served to make the pipe lines of the country common carriers *de facto*, though they are common carriers *de jure*. To-day they remain

[1] In this discussion the desirability, from an economic standpoint, of the enforcement of the legislation is not considered. The question we are interested in at this point is: Has the law been enforced? With regard to the economic desirability of its enforcement it may be noted that the large operators have raised their opposition on the grounds that 'a reduction in the minimum will bring irresponsible brokers into the field, with resultant loss to individual operators and injury to the industry as a whole,' and that it 'might interfere with the physical operation of dependents' lines and the generally satisfactory service now afforded.' (Interstate Commerce Commission, No. 11512, p. 465.) There may be something in this argument. It should also be observed that the free use of pipe lines as common carriers encourages the refining of oil by small refineries poorly equipped to extract the maximum of usable products from the crude petroleum. See Chapter XII.

[2] Report of the Committee on Manufactures, *op. cit.*, p. 48.

According to this recent report, the Prairie Pipe Line Company 'is the only one that has even a faint resemblance to a common carrier, but even that is little more than a convenience for the Prairie Oil and Gas Company, by which it was organized.' This statement is corroborated by facts presented by the Interstate Commerce Commission, according to which 90 per cent of the oil transported by the Prairie Pipe Line Company during the period 1915–19 was shipped by the Prairie Oil and Gas Company. See *op. cit.*, p. 463.

largely plant facilities for their owners, chief among which are the Standard interests.[1]

Nor does it seem that the dissolution decree has been entirely effective in freeing the production of petroleum from the dominating influence of the Standard Oil group. Crude petroleum under current marketing practices is purchased chiefly by the same interests which control the pipe lines of the country.[2] From the Standard's continued control of pipe lines and their failure to serve independent producers and refiners as common carriers, has followed the

[1] Opinion within the industry regarding the availability of pipe lines for the small shipper does not uniformly agree with the position taken above. It is averred that the explanation for pipe lines having acted in the main as plant facilities for their owners lies in the fact that there is little demand for their services on the part of the small independent shippers. (See *National Petroleum News*, March 25, 1925, p. 74.) As evidenced by the decision rendered by the Interstate Commerce Commission in the case of Brundred Brothers (see note 1, page 98) the Commission stands ready in particular cases brought before it to make available for the small shipper the service of pipe lines. It should be observed, however, that the order issued by the Commission in the case above cited applies only to two specific shipping destinations at which the Brundred Brothers' interests are located. In effect it applies, therefore, only to Brundred Brothers. The position of the writer is substantiated by the very recent investigations of the Federal Trade Commission, report of which was submitted to the President on June 4, 1924. The Commission states that the chief obstacle to the establishment of effective competition in the petroleum industry is the dominating influence of the various Standard Oil companies, each in its particular area, the principal basis of which is found 'in their control of pipe lines and in their denial to the small independent company of a practicable opportunity to ship oil under reasonable conditions.' (See *National Petroleum News*, March 4, 1925, pp. 26–27.) Mr. Nicholas, President of the National Petroleum Marketers' Association, seems to be in substantial agreement with both the writer and the Federal Trade Commission on the question of whether or not the pipe lines are in fact common carriers. *Ibid.*, p. 75.

[2] The bulk of the oil transported by the Prairie Pipe Line Company from the Mid-Continent field is either purchased or produced by the Prairie Oil and Gas Company. The Sinclair Pipe Line Company is in practice little more than a carrier for the products of the Sinclair Crude Oil Purchasing Agency. Likewise, the Magnolia Petroleum Company, the Texas Company, and the Gulf Oil Corporation, either directly or through subsidiaries, own their own transportation systems, which function almost exclusively as carriers for their own refineries.

Standard's domination in the field of production. While the Standard has had direct control of only a relatively small proportion of the total crude production of the country, it seems to have exercised, as the chief purchaser and transporter of crude, a dominating influence in the determination of the prices at which the crude product has sold throughout the major portion of the period since the dissolution. In this connection, it should be noted, that while the production of crude petroleum has remained a competitive enterprise since its beginning, the price of the crude product does not conform in any accurate manner to the 'law of competitive price.' There is no close correspondence between the cost of production and the price of the raw product. In the first place, in the mining of oil as in the mining of gold, the speculative element is of tremendous importance. The lure of vast profits has been a sufficient urge to ensure an ever-expanding petroleum production to meet the increased demands placed upon the industry. An oil gusher, the hope of every speculator, may yield enormous profits with a very low price for petroleum; while a dry hole means a loss of thousands of dollars regardless of prevailing prices. Millions of dollars are spent annually by the 'wildcatter' in an endeavor to find new producing areas with the hope of 'striking it rich,' and it has been frequently estimated that more money has been 'sunk in the ground' in an endeavor to strike a 'bonanza' than has ever been received from the sale of crude petroleum actually produced. While there is thus no close conformity between costs and prices, price variations do act as a stimulating or retarding influence to production enterprise. When demand is great a rise in price is apt to evoke renewed efforts, while a fall in price will eventually serve to slow down development operations. In the second place, once a well has been completed, the force of competitive circumstances and natural conditions of oil production impel the owner to permit his well to run at full capacity and to dispose of his product at whatever price it may bring. He cannot afford to refuse

to sell his product at prevailing prices. To 'close in' his well affords a competitor on a neighboring tract the opportunity to drain the oil from under the owner's tract. Thus, once development is under way, the owner of a producing well is bereft, in large part, of bargaining power in the sale of his product. There might well be competition among purchasers of crude, however, that would ensure a genuinely competitive price. But, as stated, the purchasing of crude oil has been in the hands of a relatively few large concerns, chief among which is the Standard group. As the largest purchaser in the country, the Standard interests have exerted about the same influence in determining the price of crude oil as they have in determining the price of the refined products. The Standard has led the way; independents have followed. The Standard's posted price has been the prevailing price. Not always, of course, nor everywhere, but as a general rule, the Standard has set the pace.

The situation in the California fields is well set forth by the Federal Trade Commission in its report of November 28, 1921:[1]

> A practice of great significance that had become established in the Pacific Coast petroleum industry is that of basing contract prices for crude petroleum upon the market price as announced by the Standard Oil Company and of providing that an increase or decrease in the Standard's announced price during the life of the contract shall cause a corresponding change in the prices paid under the contract. The practice of making such contracts is quite general for the purchase of crude petroleum, and also in the sale of fuel oil, and such contracts are made to some extent for the sale of other petroleum products. The significance of this practice is that a price change by the Standard automatically causes the same change in the prices of other companies. Even the Union Oil Company, which is the second largest marketing company in California, agrees to pay the 'published schedule price offered by the Standard Oil Company,' for the royalty portion purchased from the owner on oil lands which it leases, and the prices which it pays members of the Independent Oil Producers' Agency are also based on the Standard's announced prices.

[1] *Pacific Coast Petroleum Industry, op. cit.*, part II, pp. 30–31.

Nor has the situation been substantially different in other fields. The Prairie Oil and Gas Company has generally posted the price of crude in the Mid-Continent field, other companies meeting the price as posted by this concern. Likewise, the South Penn Company or the Seep Purchasing Agency, both Standard-controlled companies, have dominated the price situation in the Appalachian fields. Of recent years, however, in the rapidly developing Mid-Continent territory there has been a growing tendency for certain of the larger independents to establish their prices without regard to the Standard charges, the Sinclair Company being particularly active in this regard.

It may be, too, that in certain limited producing sections, independent companies, by reason of their greater production and early establishment of pipe-line connections, have continuously dominated local areas. Independent refineries located in the oil-field regions have likewise purchased in the aggregate a considerable volume of crude; but in general they accept the Standard's posted price as a basis for their purchases, although they are forced to pay a premium over this posted price in order to be assured of an adequate supply of crude. At best they have led a precarious existence and until very recently seem to have been of little importance as a factor in determining the price of crude.[1] In general, the statement holds true for the purchase of crude petroleum as for the sale of refined products that the Standard group has dominated the field.

What conclusion can be drawn from the foregoing analysis regarding the position of the Standard Oil Company in the industry? We recur to the question: Has the dissolution

[1] By paying a premium over the posted price for crude independents were able to secure the more valuable grades of crude. This fact seems to have been a factor in bringing about the change in method of posting crude prices employed by the larger companies. Prior to November, 1922, one barrel of Mid-Continent crude was considered the same as another by the larger companies, all grades of oil in a particular locality being bought at a uniform price. Since that date the prices posted by the larger companies have varied with the specific gravity of the crude, light oils bringing a higher price than low gravity oils.

decree been successful? Has the oil industry been genuinely competitive since 1911? It is true that a large volume of independent capital has flowed into the oil industry since the dissolution of the Standard Oil Company of New Jersey and that the independent companies to-day transport, refine, and market a much greater proportion of the total output of petroleum and its products than they did at the time of the dissolution. But the segregated Standard companies have continued, in the main, to function as working units in a comprehensive, specialized, industrial mechanism engaged in the production, purchase, transportation, refining, and marketing of crude petroleum and its products. In each of the different industrial and geographic fields in which the various members of the old Standard group operate, a Standard company has remained the leader, and the Standard companies in the aggregate handle approximately as large a volume of traffic to-day as all the independents combined.

In view of the large volume of traffic which they have controlled and the recognized power of their leadership, Standard interests seem to have exerted a determining influence in the regulation of prices both of crude petroleum and its refined products. The Standard companies have set the pace; the independents have, with great consistency, followed. Standard Oil interests seem to have dominated the industry throughout most of the period since the dissolution decree.

Conditions in the oil industry have been changing with remarkable rapidity, however, and within the very recent past counter-tendencies may be noted. Economic forces have apparently quite recently engendered a conflict of interests between the various Standard companies themselves which seems to threaten a genuine dissolution of the Standard organization. It will be recalled that at the time of the dissolution decree a marked characteristic of the Standard organization was the specialized productive activities of the various constituents. Production, transporta-

tion, refining, and distribution were in the main conducted by separate companies specializing in a single activity. Each constituent formed a specialized unit in a comprehensive industrial whole. The dissolution decree apparently did not immediately interfere to any great extent with this working arrangement and throughout most of the period since 1911 the various companies seem to have functioned largely in the same capacity as prior to the decree. The organization has been bound together more loosely, however, the force of custom and the intangible influence of a community of interest among the owners being apparently the sole factors at work to ensure its maintenance. The marked interdependence of various companies' activities in the absence of a definite, legally constituted control to ensure the maintenance of the working balance between the constituents, created a condition of unstable equilibrium, a situation latent with insecurity, especially for the more highly specialized constituents engaged in the later stages of the industry and dependent upon the production companies for an adequate supply of crude petroleum. The situation was aggravated by the constantly increasing demand for petroleum products, and a constantly decreasing underground supply of petroleum.

During the war the supply of crude petroleum was outdistanced by the demand for the refined products, and stocks were drawn upon almost continuously from 1915 to 1918. At the same time the idea was gaining ground that the petroleum resources of the United States were so limited that a period of petroleum shortage might not be far distant. This belief was given a scientific basis by the authoritative estimates of geologists of note regarding the ultimate yield of petroleum which this country may afford. The conviction grew that the United States was facing a shortage of oil and that we were soon to become dependent upon foreign sources of supply.[1] In the face of this situa-

[1] The sentiment expressed by Mr. J. E. O'Neill, president of the Prairie Oil and Gas Company, in his testimony before the Senate

tion, the more aggressive Standard companies, which formerly engaged chiefly in refining and marketing, have apparently been unwilling to rely entirely or chiefly upon the Standard companies specializing in the production and purchase of crude oil as the sole source of their supply. Within recent years a number of these concerns have accordingly taken measures to ensure themselves an independent source of supply of this rapidly diminishing resource. Attention has already been called to the acquisition by the Standard Oil Company of Indiana of the Mid-West Refining Company with its extensive and valuable properties in the Rocky Mountain field; to the acquisition by the same organization of a half interest in the Sinclair Pipe Line Company, formerly one of the largest independent purchasers and transporters of crude petroleum in the entire country; to the acquisition by the Standard Oil Company of New York of the Magnolia Petroleum Company with its extensive facilities for the production, purchase, transportation, and refining in the southern section of the Mid-Continent field; and to the acquisition by the Standard Oil Company of New Jersey of the Humble Oil and Refining Company, a completely integrated company with large holdings in the Southwest. These acquisitions have affected the harmonious activities of the formerly interdependent and non-competing Standard companies in two respects: in the first place, they have brought formerly non-competing Standard units into genuine, or ostensible, competition with each other in certain areas; and in the second place, they have disturbed seriously the working balance of inter-company activities. Thus, prior to its

Committee on December 22, 1922, typifies the general belief prevailing in the industry at large throughout the past few years. 'My own opinion is — and this is arrived at after most careful thought and study in various fields — that the United States has seen the peak production in crude oil. I want to go on record here as stating that, in my judgment, in ten years or less it will be necessary for the refiners of this country to secure at least 50 per cent of their product from outside countries.' *Hearings*, *op. cit.*, p. 247.

acquisition by the Standard interests, the Humble Oil and Refining Company was an active competitor of the Magnolia in the Southwest; and these concerns continue to compete for business in the same territory. Likewise, the acquisition by the Standard Oil Company of Indiana of a half interest in the Sinclair Pipe Line Company and the formation of the Sinclair Crude Oil Purchasing Company, jointly owned by the Standard Oil Company of Indiana and the Sinclair Consolidated Oil Company, brought the Standard Oil Company of Indiana into competition with the Prairie Oil and Gas Company in the purchase and transportation of crude petroleum. But of greater importance is the fact that it robbed the Prairie of one of its biggest customers and thereby forced the Prairie to look elsewhere for a market for its crude.

Recently, too, the Standard Oil Company of New York, through the Magnolia Petroleum Company, has been extending its sources of crude supply. The Magnolia Company, which formerly confined its purchasing activities largely to the southern portion of the Mid-Continent field, has recently extended its line as far north as the Burbank field in Oklahoma and it is reported that it may eventually extend to the northern extremities of the Mid-Continent area in Kansas.[1] This extension has brought the Magnolia into more active competition with the Prairie Oil and Gas Company particularly in the purchase of high gravity oils.[2] The Standard Oil Company of New Jersey has further fortified its competitive position through the purchase by its subsidiary, the Oklahoma Pipe Line Company, of a small portion of the Prairie pipe line to the South which connected the lines of the Oklahoma Pipe Line Company directly with the line of the Standard Oil Company of

[1] See *Oildom*, December, 1923, p. 25.

[2] During September, 1923, the Magnolia's runs from Oklahoma and Kansas are said to have averaged 26,000 barrels daily, of which amount 10,000 barrels daily of high gravity oil were secured from the Cushing, Yale, Duncan, and Burbank fields. See *National Petroleum News*, November 7, 1923, p. 69.

Louisiana, which is likewise owned by the Standard Oil Company of New Jersey. With this connection the New Jersey's subsidiaries owned a complete and independent line from Oklahoma to Baton Rouge. The New Jersey Company has since used this outlet as a means of further increasing its crude supply. In the early part of 1923, the Standard Oil Company of New Jersey entered into contract with the Marland Oil Company for the delivery within one year of six million barrels of crude oil to be supplied from the Tonkawa field in Oklahoma. The Oklahoma Pipe Line connected with the Marland line and all the crude so purchased has been run by the Standard of New Jersey's own lines to Baton Rouge, and from there by tank steamer to its Atlantic Coast refineries. Similarly, the production of the Carter Oil Company, another subsidiary of the Standard of New Jersey, has been run through the same line, and this has resulted in a further loss of business to the Prairie Oil and Gas Company and the Prairie Pipe Line Company.[1]

Just as a potential shortage of crude petroleum has tended to disturb the working balance among the constituents of the Standard Oil group, so the recent overproduction of crude petroleum has worked toward the same end. It has resulted in a further conflict of interests among the members of the Standard group and has injected a new element of competition into the situation.

The growing idea of an approaching domestic shortage of petroleum seems to have reached an acute stage by 1919. This year witnessed a spectacular rise in the value of oil securities. The following year saw an increase of more than 50 per cent in the price of crude petroleum which reached a figure more than three times that of the pre-war level of 1913.[2] Contemporaneous with these developments there was a tremendous influx of new capital into the industry during 1919 and 1920. A growing conviction of

[1] *Oildom*, December, 1923, p. 25.

[2] See Pogue, Joseph E., *The Economics of Petroleum* (New York City, 1921), p. 236.

an approaching shortage of crude petroleum, a rise in the price of petroleum products, a rapid influx of new capital — these factors seem to have acted as a stimulus to the development of a new technique and a broader application of the old technique to oil-field methods, with the result that from the latter part of 1920 until the close of 1923 there was an almost unbroken period of overproduction.[1] Oil has been found faster than it has been consumed. The result has been a persistent accumulation of stocks up to the close of 1923.[2] Pipe-line and tank-farm stocks for the entire country showed an increase from 133,690,000 barrels at the close of December, 1920, to 322,229,000 barrels at the close of November, 1923. Crude oil stocks at refineries increased during the same period from 21,260,580 barrels to 33,012,005 barrels, and the stocks of liquid refined products at refineries increased from 59,067,346 barrels to 103,524,333 barrels. Overproduction, while general, has been particularly acute in the California area. California's average daily production increased from 323,806 barrels for the month of December, 1920, to 858,750 barrels for the month of September, 1923, an increase of 165 per cent; while during the same period the average daily production for the balance of the United States increased from 933,000 barrels to 1,286,317 barrels, an increase of 37.8 per cent.[3]

Throughout 1920 California's consumption had exceeded production and stocks had shown a persistent decline. With increasing production and depressed conditions in industry, this situation was reversed with the opening of 1921, and stocks increased with little interruption throughout the year. With supply running somewhat ahead of demand, the price of crude oil as posted by the Standard Oil Company of California was lowered on May 13 and

[1] For a detailed statistical analysis of the recent overproduction and a theory of its causes, see Pogue, J. E., 'The Effect of Improved Technique on Industry,' *The Oil Weekly*, January 26, 1924, pp. 19–22.

[2] The increase in stocks continued throughout the first eight months of 1924.

[3] Data from American Petroleum Institute.

again on August 13, 1922. Despite lowered prices, production increased steadily throughout 1922; and in 1923, due to rapid and extensive developments in the Santa Fé Springs, Long Beach, and Huntington Beach fields, the rate of increase was further accelerated until by August, 1923, California was yielding more than 40 per cent of the total domestic production. This situation had been met with another reduction in price on January 8, 1923, and a still further reduction on April 16, 1923. As a result of these successive price reductions, California crude which prior to 1922 had found its market almost exclusively on the Pacific Coast, literally pushed its way into the refinery markets of the East. Shipments of crude oil were first made from California by way of the Panama Canal for the Atlantic Coast late in 1922. By the early spring of 1923 California petroleum had made considerable inroads into the Eastern market of Mid-Continent producers. Throughout April the daily receipts of California crude on the Atlantic Coast averaged 146,633 barrels. By August this daily average had increased to 175,935 barrels. While available data does not indicate definitely the recipients of these shipments, it has been reported that the several Eastern Standard marketing concerns, including the Standard Oil Company of New Jersey and the Atlantic Refining Company, are among the more important purchasers.[1] Both these companies, it should be noted, have been long-established customers of the Prairie Oil and Gas Company from whom they have consistently secured a large part of their crude supply. With the Standard Oil Company of California able and willing to supply high gravity crude oil at their Eastern refineries at a lower price than that demanded by the Prairie Oil and Gas Company, these Eastern Standard companies, unrestrained by sentiment, suspended in part their purchase of crude from the Prairie Oil and Gas Company.[2]

[1] See *National Petroleum News*, March 7, 1923, p. 25.
[2] *Idem.*

As a result of these several developments, the Prairie Oil and Gas Company, for many years the largest purchaser and seller of Mid-Continent crude, has found its larger customers independently taking care of their own crude oil requirements. Confronted with the loss of an important outlet for its crude[1] the Prairie has undertaken to find new and more dependable markets. Realizing the insecurity which its lack of integration entailed, the Prairie is apparently seeking a market for its crude oil more directly under its own control. Thus in the latter part of October, 1923, announcement was made of a plan whereby the Prairie Oil and Gas Company was to secure a controlling interest in the Producers and Refiners Corporation.[2] By December 1, 1923, this plan had been put into operation. Through its execution the Prairie immediately became a completely integrated company, engaging in all branches of the oil industry. The acquisition of the new company increased the Prairie's production of crude petroleum by about 20,000 barrels per day and greatly strengthened its position in this branch of the industry in the Wyoming field. It gave the Prairie control of three refineries, two adjacent to the Oklahoma field and one in the Wyoming territory, with a total daily capacity of approximately 20,000 barrels per day. It likewise gave the Prairie control of the marketing facilities of the Hawkeye Oil Company, a subsidiary of the Producers and Refiners with headquarters at Waterloo, Iowa. These marketing facilities include several

[1] The Prairie's growing insecurity was aggravated by the construction by the Sinclair Pipe Line Company of a pipe line from the Wyoming field to Kansas City. It was expected by the industry (see *Oildom*, *op. cit.*, p. 25) that this pipe line with its 40,000 barrels capacity would give the plants of the Standard Oil Company of Indiana access to a large part of their additional crude requirements. The decline of production in the Salt Creek field seems not unlikely to cause disappointment in this regard, however. (See *National Petroleum News*, March 18, 1925.)

[2] See *National Petroleum News*, October 31, 1923, p. 17. The plan provided for an exchange of stock on a basis of one share of the Prairie stock for ten shares of the Producers and Refiners.

hundred filling stations and bulk stations in the heart of the trade territory of the Standard Oil Company of Indiana. By their acquisition the Prairie secures a large-established business in well and favorably known gasoline and other petroleum products sold under the trade name, 'Parco.'

This radical departure by the Prairie from its time-honored position of being solely a producer and broker of crude oil—a position so strongly adhered to that the Prairie has never even manufactured gasoline on its own leases—marks an important event in the history of the Standard Oil companies.[1] It indicates strongly that the old Standard Oil Company is crumbling from within. Apparently economic forces have been working to bring about a genuine disintegration of the old organization, a result which the dissolution decree of itself had not been able to accomplish.

Developments in this regard have proceeded with rapidity. On April 1, 1925, announcement was made of the purchase by a syndicate composed of Blair and Company, New York City, interests identified with the Chase National Bank, New York City, the Standard Oil Company of Indiana and certain British interests of a controlling interest (501,000 shares of the 1,001,556 outstanding voting stock) in the Pan-American Petroleum and Transport Company. This stock is now under the control of the newly organized Pan-American Eastern Petroleum Corporation. There is anticipated a separation of the western and eastern properties of the Pan-American Petroleum and Transport Company, the western properties to continue under the control of the Doheny interests, the eastern under the control of the Pan-American Eastern Petroleum

[1] It is reported that the Prairie Oil and Gas Company has petitioned the Supreme Court of Kansas to remove certain restrictions imposed upon it in 1910 by a court decree which forbade the Prairie's engaging directly in any other business in Kansas than that in which it was engaged when the decree was issued. This action has been interpreted in the industry as an evidence of the Prairie's intention to further expand the scope of its refining and marketing activities. See *National Petroleum News*, February 20, 1924, p. 20.

Corporation allied with the Standard Oil Company of Indiana. This new alignment, carrying as it does control over large production properties in South America and Mexico, gives greater assurance to the Standard of Indiana of an adequate future supply of crude petroleum. It also, through control over extensive refining and marketing facilities in the southern and eastern sections of the United States, brings the Standard Oil Company of Indiana into competition in the marketing of petroleum products with the Standard Oil Company of New Jersey, the Standard Oil Company of Kentucky, the Standard Oil Company of New York, the Atlantic Refining Company, and the Magnolia Petroleum Company. East of the Rockies only the Standard of Nebraska and the Standard of Ohio seem to escape the Standard of Indiana's competition. The acquisition of a controlling interest in these properties by the Standard Oil Company of Indiana has been heralded in the petroleum press as 'by far the biggest occurrence in Standard Oil circles since the dissolution suit in 1911' and as perhaps possessing a 'more far-reaching effect than that suit.'[1]

The foregoing analysis indicates that the dissolution decree in and of itself did not establish competitive conditions in the oil industry. Throughout most of the period under review, the Standard group seems to have dominated the situation almost as effectively as prior to the decree. The decree, however, did decentralize the control of the constituents. The working balance between these dissolved units, to the extent that it has since been maintained, has depended largely upon the intangible influence of a community of interest on the part of a more or less common group of stockholders, and upon the forces of economic advantage and custom. With a rapidly expanding demand for petroleum products, a demand apparently yet in its infancy, and a growing conviction of the approaching exhaustion of our domestic petroleum reserve, the more

[1] *National Petroleum News*, April 1, 1925, p. 34.

aggressive Standard concerns have endeavored to fortify their positions for the future by the acquisition of independent sources of supply. The development of this programme has led to a conflict of interests within the old Standard group. It has made imperative a counter-policy of expansion on the part of other Standard concerns. The execution of these counter measures of self-defense have led to a further overlapping of interest until to-day it seems not unlikely that the interdependence of the various Standard companies is approaching an end. It may be that the force of economic circumstances will yet make the oil industry genuinely competitive and free.[1]

[1] It is scarcely to be presumed, however, that such free competition between Standard units would be directed primarily toward an increase in volume of business through competition in prices. The more modern and generally accepted principle of salesmanship directed toward the creation of good will and prestige would no doubt continue to dominate the situation. It seems not unlikely that a recognized 'market leader' would continue to set the pace in matters of price.

CHAPTER VII

THE NATURE AND OCCURRENCE OF PETROLEUM

In the preceding chapters we have traced in outline the development of the oil industry in the United States. Very early in the history of the industry control was centered in the Standard Oil Company and its subsidiaries. While the industry was thereafter conducted under the broad principles of the competitive system, that is, on a basis of private ownership and operation for private gain, the active forces of competitive business rivalry had to a large extent disappeared in three branches of the industry. By its control of those three branches, the Standard interests exercised a dominating influence over the industry in all its stages. We have also traced the development of our governmental attitude toward this centralization of ownership and control, a prevailing attitude toward industry at large during the latter quarter of the nineteenth century. Our governmental procedure has been guided by the belief that the competitive system is a righteous system and that competitive business rivalry is perhaps its chief source of righteousness.

This attitude as directed toward the petroleum industry has resulted in a misplaced emphasis—an emphasis (mis)-placed so gently as to have had little effect. Our Government's concern has been with regard to the dominating power of the Standard Oil interests and in this respect its efforts seem to have been far from successful. The oil industry has been expanding with great rapidity, however, and there has been an enormous increase in the amount of independent capital invested in it. The output of the industry is not as centralized as at the time of the Standard dissolution. The profits, likewise, are not as concentrated

now as formerly. A somewhat larger group share in the price rewards of petroleum enterprises.

To private initiative actuated by the profit motive under an unrestricted competitive régime we would turn for a remedy of the ills of monopoly. Hence the application of the Sherman Act and the ostensible dissolution of the Standard Oil Company. The foregoing discussion indicates that the dissolution in and of itself has attained only a modicum of success, but that within the very recent past economic forces have engendered a situation which may augur the establishment of a genuinely competitive order. But putting aside the question of the effectiveness of our policy of federal control, that policy, in so far as the oil industry is concerned, has been marked by an ignorance of the real problems involved. It is the result of a prejudice, a hangover from an antecedent industrial régime. Our social group, clinging to its old habits of thought, but confronted by changed material and economic circumstances, has sought refuge in tradition. The result in the case of the oil industry has been a considerable expenditure of energy on the part of Government agencies with little to show for it.

A basic point of departure in the formulation of a policy of federal control and its intelligent application to particular industries should be a comprehensive understanding not only of the social problems involved, but of the more technical and economic problems peculiar to particular industries. Competition, in either its narrower or broader significance, in the oil industry means waste — waste on a spectacular and magnificent scale. While our lawmakers have been concerned with the matter of prices and profits and monopoly control, oil production in this country has been carried on in a wasteful and improvident fashion, the development of transportation has been characterized by needless expenditure, and the refining industry has failed to take account of the full range of petroleum values. To the extent that the industry has been competitive, the

situation from an engineering and industrial standpoint has been increasingly demoralized. In the following chapters we wish to analyze in some detail the wastes which necessarily characterize and accompany the oil industry under an unrestricted competitive régime. We wish to test the accuracy of the statement that 'from the moment oil is struck in some barren patch of prairie until any one of the many products of crude petroleum is placed in the hands of the consumer' there is no waste. In making the test we shall endeavor to get at the basic causes of the wastes encountered, and thereby to set forth in a clearer light the inadequacy and futility of our attempted policy of social control.

Let us turn first to the problem of oil production. Although the Standard Oil Company at an early date secured practically a monopoly control of the transportation, refining, and marketing of petroleum, it should be borne in mind that oil production has remained a highly competitive enterprise throughout the history of the industry. Despite the foregoing quotation, among those familiar with oil-field methods, it is a matter of common knowledge that the production of crude petroleum in the United States has been accompanied by tremendous wastes. Nor has there been a dearth of suggestions as to practical and scientific remedies for such a situation. Petroleum technologists through publications of the Bureau of Mines, the United States Geological Survey, various State organizations, and in scientific oil and mining journals have from time to time pointed out in some detail the nature of these wastes, with suggestions as to the remedies that might profitably be applied. While the literature concerning the subject is, therefore, fairly replete both with facts regarding the wastes and with proposals of remedies, the wastes in oil production since the incipiency of the industry in 1859 until the present time have not been greatly mitigated, and the discovery of each new field has witnessed in whole or in part a repetition of the wasteful and destructive practices that have gone before.

That the discovery and development of a new industry, with its attendant technological and engineering problems, should be accompanied by waste during the period of experimentation and adjustment is perhaps unavoidable. That such wastes continue long after the development of the scientific and engineering technique necessary for their elimination, would seem to indicate a fundamental defect in the system of petroleum exploitation. Why is there such a divergence between the accumulated store of petroleum technology and that portion which finds its application in the industry? Why are the outstanding wastes of yesterday the outstanding wastes of to-day with little differentiation as to degree or kind? Are the petroleum technicians at fault? Does the blame lie with the operators? An affirmative answer to these last two questions may contain a modicum of truth, but in neither case does it furnish a satisfactory explanation of the issues raised.

Rather, the fault would seem to lie with the system. The scientific and economical development of oil production is opposed rather than promoted by the competitive system. There is lack of adjustment between the geological occurrence of petroleum and the manner of its industrial exploitation, the inevitable result being waste and confusion. The succeeding chapters will be devoted largely to a development of this thesis.

During the course of the argument a number of generalizations are entered into, to which there are, no doubt, numerous exceptions. They stand true, however, where the competitive system has been allowed to work itself out, unhampered by what the operators frequently regard as unnecessary State interference. Certain States have instituted rather close supervision in regard to certain phases of the problem, notably Texas, Oklahoma, and California, and each of these States has within the recent past made considerable progress in particular directions, but no State seems to have solved the problem in the large.[1]

[1] Oklahoma and Texas have apparently greatly lessened the waste

The writer wishes to emphasize at the outset of the discussion of waste in oil production that adequate State legislation now exists to prevent much of the waste subsequently described in detail. He also wishes to emphasize the fact that this legislation has failed to a considerable degree to accomplish its object, primarily because it fails to take account of the maladjustment between the geological occurrence of petroleum and the competitive methods of exploitation. The legislation seeks to prevent waste by forbidding it. Competitive extraction of petroleum encourages and frequently necessitates waste. The result is that the laws in all localities have been disregarded or evaded at some points, and in some localities at all points. Not only is the legislation somewhat vitiated by its failure to take account of the fundamental nature of oil production, but the administrative machinery for its enforcement is generally inadequate for the task involved. To the extent that petroleum production has been an unrestricted competitive enterprise, it has been a venture accompanied by waste. When, and to the extent that some form of unified control has been instituted under intelligent direction, a more economical exploitation has been approached.

In order that the full significance of the analysis may be readily comprehended, it will be well to take a glance at the present status of the resource, its past productive accomplishments, the probable future demands, its geologic occurrence and the mechanism of its exploitation.

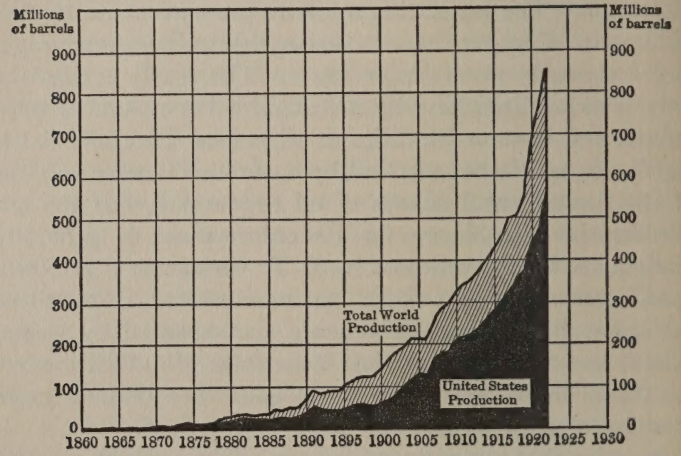
Since the discovery of crude petroleum in commercial quantities in 1859, there has been a tremendous increase in its annual domestic production. (See Figure VI.) This increase has been particularly marked since the opening of the twentieth century. Annual production for the year 1900 was 63,621,000 barrels. Since this date, with the exception of the year 1906, production has shown an un-

of gas, and Texas has made some progress toward the matter of well spacing. California has done little in this regard, but apparently leads the field in dealing with the water problem.

interrupted increase. From 1900 to 1910 annual production increased more than threefold. By 1920, domestic production had again more than doubled.

Despite the tremendous increase up through 1920, the last three years have seen our annual petroleum production

FIGURE VI. A COMPARISON OF THE PETROLEUM PRODUCTION OF THE UNITED STATES, WITH THE TOTAL FOR THE WORLD, FROM 1860 TO 1923

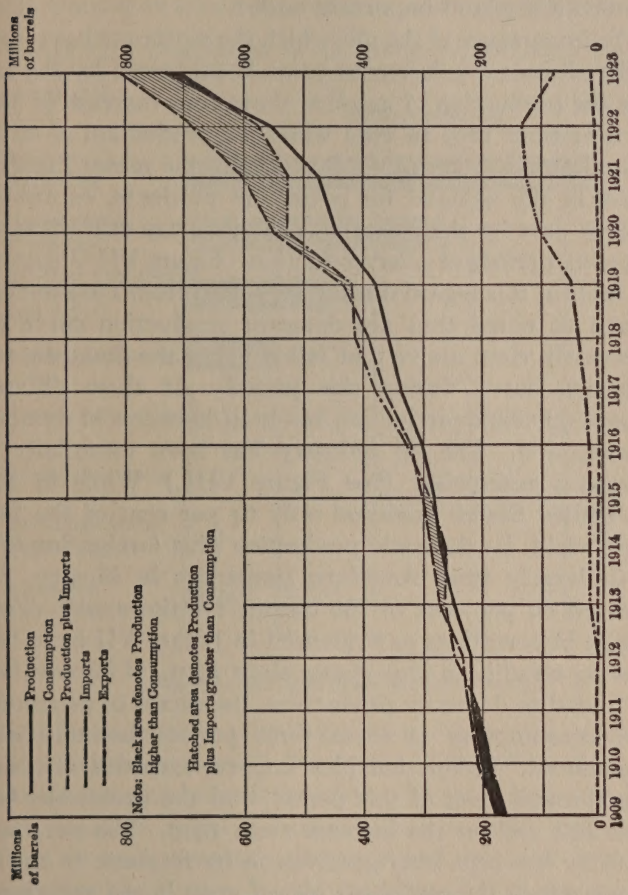


(Data from the United States Geological Survey.)

show a further increase of more than 63 per cent, the production of 1923 reaching the enormous total of 732,407,000 barrels.

Since the incipiency of the petroleum industry production has tended to run somewhat ahead of the demand for petroleum products. Because our supply of petroleum has been continuously bounteous it has tended to shape, and in some instances, has actually created demand by calling new uses of oil into being. In the early stages of the industry, when kerosene was its chief commercial product, a plentiful supply necessitated the development of foreign markets for disposal of the domestic surplus. Once a market was created the new demands reacted upon production calling

FIGURE VII. SHOWING UNITED STATES CRUDE OIL PRODUCTION, CONSUMPTION, PRODUCTION PLUS IMPORTS, IMPORTS, AND EXPORTS, IN MILLIONS OF BARRELS, FROM 1909 TO 1923



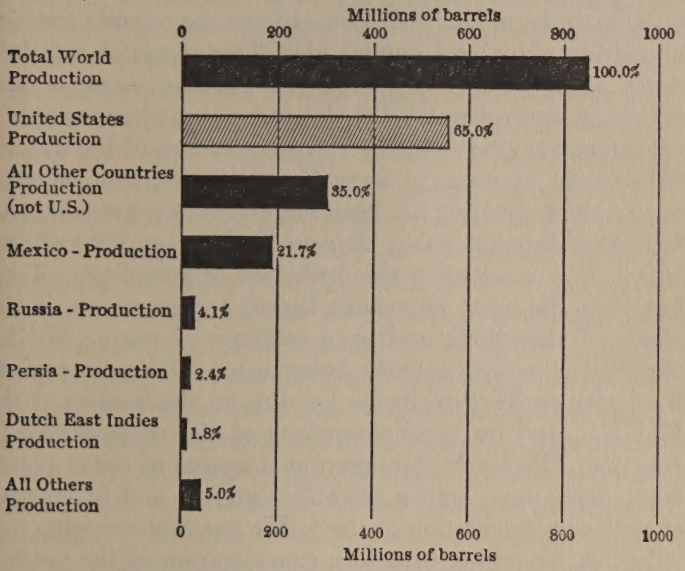
(Data from the United States Geological Survey.)

forth a further supply. An overabundant supply was forthcoming without delay and this has necessitated a further development of new markets. Since the opening of the twentieth century the development of the automobile has afforded a new and important outlet.

The importance of the rôle which the motor car has played in the oil industry in recent years is evidenced by the fact that the production of gasoline showed an increase of 2208 per cent from 1899 to 1922 while the production of oil increased only 966 per cent. But despite the recent rapid increase in the demand for petroleum products, occasioned in large part by the motor car, the industry still witnesses recurring periods of overproduction. Figure VII illustrates the facts in this regard during the period from 1909 to 1923. It will be noted that the domestic production curve has alternately risen above and fallen below the domestic consumption curve during this period. At three different periods domestic production has been in excess of domestic consumption. The oil industry has been essentially an American enterprise. (See Figure VIII.) While in 1922 the United States produced only 64 per cent of the total world yield, its domestic production plus foreign importations, largely from American properties in Mexico, represented 80 per cent of the output for the world. These foreign importations as evidenced in Figure VII have been growing steadily in importance since 1910. If importations are added to domestic production, the excess of production over consumption at these three periods becomes more pronounced. Production plus imports exceeded consumption through most of this period, and the excess has been sustained and on the increase since 1919. The petroleum industry has been over-generous in its response to the demands which the motor car placed upon it and recurrently we have been confronted with the problem of disposing of our surplus oil. New uses have been created, and since 1900 oil has become of considerable importance as a fuel for steam-raising purposes. Some of our surplus oil has been

burned as a fuel substitute for coal. Industry at certain points has become accustomed to this convenient and cheap fuel and these new uses have contributed to a further increase in the demand for petroleum. Despite the remarkable manner in which the industry has responded there has

FIGURE VIII. COMPARISON OF THE UNITED STATES CRUDE OIL PRODUCTION WITH THE PRODUCTION FOR THE REST OF THE WORLD FOR 1922



(Data from the United States Geological Survey.)

been for some time a feeling that our domestic supply will soon be unable to meet the demands placed upon it. This belief seems to be well founded. At three intervals in the past fourteen years domestic production has been insufficient to meet domestic demands and we have been compelled to draw upon foreign supplies. There are as yet no satisfactory substitutes for gasoline or kerosene as fuel for the internal combustion engine. The production of automobiles continues apace. The seven-year period from 1918 to 1924 witnessed an increase of approximately 175 per cent

in the number of motor cars registered in the United States.[1] The application of the tractor to the farm has thus far been very limited and the aëroplane industry is yet in its swaddling clothes. All this betokens a continued increase in the demand for petroleum products.

Such a situation would seem to justify a more careful consideration of our petroleum supply. Current theory now most generally accepted by geologists indicates that crude petroleum has been formed from the organic remains of marine plant and animal life. This material was laid down along ancient seacoasts, in lagoons, swamps, and deltas, in water-deposited shales and clays, where complete oxidation was prevented by the quiet nature of the waters. Other beds of material have been superimposed on this, until a thick covering has been formed. Time, pressure, and heat have brought about changes in these organic remains which have resulted in the formation of petroleum. Time has been the most important factor, for petroleum is the result of thousands and even millions of years. Similar depositions are apparently being made to-day in regions bordering on Sweden, in the Levant, on the borders of the Red Sea, and on certain portions of the coast of North America. Obviously, however, as a source of crude petroleum these have only a scientific interest and in no way enter into a calculation of the future available supply.

Let us, therefore, turn to a consideration of the present and more immediately prospective producing areas. As previously stated, the chief producing fields of this country in the order of their output for 1923 are: (1) Mid-Continent, embracing portions of Kansas, Oklahoma, North Central Texas, Northern Louisiana and Southern Arkansas; (2) California; (3) Rocky Mountain, including portions of Wyoming, Montana, and Colorado; (4) Gulf Coast, embracing the coast country of Texas and Louisiana; (5) Appalachian,

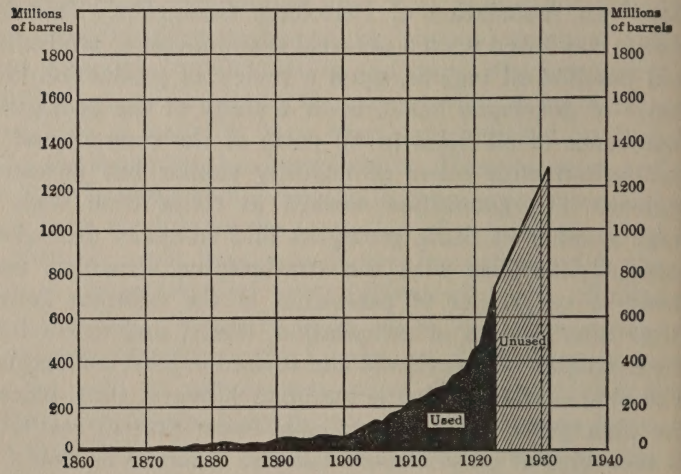
[1] It is interesting to note that in 1924, 87 per cent of all the motor vehicles of the entire world were in use in this country. (Preliminary figures, National Automobile Chamber of Commerce.)

embracing portions of New York, Pennsylvania, West Virginia, Eastern Ohio, Kentucky, and Eastern Tennessee; (6) Illinois and Southwest Indiana; and (7) Lima-Indiana.

In response to the growing interest of the public in the problem, several estimates have been made of the magnitude of our undeveloped petroleum reserves. The most recent and perhaps the most authoritative of these estimates was made by representatives of the United States Geological Survey working in conjunction with representatives of the American Association of Petroleum Geologists. This estimate was based upon a personal examination of producing and possible oil regions, upon a review of production histories of developed fields, upon a study of the geological occurrence of oil fields in all parts of the country and a comparison with other geologically similar but untested regions. The committee worked in coöperation with a large number of State geologists and company geologists especially familiar with the stratigraphy, structure, and mode of occurrence of petroleum in the different fields. After nine months of compilation, study, and discussion, the estimates were reviewed and revised in joint conference. The final estimate as made public in January, 1922, placed the underground reserve available under present methods of recovery, at 9,150,000,000 barrels. There is no doubt a possibility of great error in such an estimate since it is little more than a scientifically calculated guess; but it represents the balanced judgment of a group of chosen specialists, experts in their field. More than four billion barrels of this estimated reserve are said to consist of heavy oils with a relatively small gasoline content. Our total domestic production of petroleum for 1922 and 1923 equalled 1,289,900,000 barrels. On a basis of the foregoing estimate, there yet remained on January 1, 1924, an available underground supply of petroleum of some 7,800,000,000 barrels. Since the discovery of the Drake well in 1859, this country has produced in round numbers 7,192,000,000 barrels of crude oil, or approximately 50 per cent of the estimated original

underground supply. More than one third of this amount has been produced within the last five years. If our annual production were to show the same rate of increase that it has evidenced during these last five years, by the middle of 1931 our estimated petroleum supply would have become exhausted. (See Figure IX.) The estimate, of course, may

FIGURE IX. SHOWING THE ESTIMATED TOTAL ORIGINAL PETROLEUM SUPPLY IN THE UNITED STATES, THE PORTION USED, AND THE PRESENT TENDENCY IN RESPECT TO THE UNUSED RESERVE



(Data from United States Geological Survey. After Gilbert and Pogue, United States National Museum, Bulletin 102, vol. 1, Fig. 7, p. 54.)

be very much in error; it was purposely conservative and many believe it to be too small. It seems unlikely, however, that the production performance of the past five years will be repeated. However great may be the disagreement among the experts regarding the order of magnitude of our underground petroleum supply, there seems to be general agreement that it will be physically impossible to project the production increase of the past decade into the next decade. The peak of production of an individual well is reached very early in its life, after which a steady decline sets in. Likewise, individual pools sooner or later reach a

maximum output and thereafter undergo, perhaps a prolonged, but nevertheless a certain decline. Just as surely the aggregate production of all the pools in this country will ultimately reach their peak and thereafter decline. This decline, when it does begin, will no doubt be interrupted from time to time by the discovery of new pools and the extension of old ones; and it seems likely that this country will yield petroleum for generations to come.

During the sixty-three years in which oil has been produced in this country there have been sixteen pools which at their peak have attained a maximum daily output of more than 100,000 barrels. Eight of these reached their peak in 1923, and it is this fact which accounts for the tremendous total production of that year. Already, the daily average production for the United States has declined from 2,280,000 barrels in September, 1923, to 1,880,000 barrels in March, 1924.[1] It may be that the decline is only temporary and that in the future the oil industry may outdo for a short period its performances of the past. But a fundamental fact in the petroleum situation is that oil is a wasting asset. It is not reproduced overnight. Whatever may have been the magnitude of our original underground supply, it has undergone a considerable shrinkage. The layman may believe what he will, but the men best informed on the subject seem convinced that the original reserve has been so greatly depleted that a permanent decline in our domestic production may be expected within the next few years.

While America has thus far contributed the major portion of the total world production of petroleum it is believed that there are fields, outside this country, in the main undiscovered, which may yield in the aggregate perhaps ten times as much oil as may yet be secured from our unmined reserve.[2] Of course, any estimate of the unmined world

[1] Preliminary figures for 1924 indicate a decline in domestic output of 25,142,000 barrels from 1923.

[2] Mr. David White, chief geologist of the United States Geological

supply is a mere conjecture. Foreign resources may exceed or fall short of their expectation. It is a fact, however, that much of the expected foreign supply is yet to be located, that its extraction and transportation may be complicated by physical and political difficulties, and that it may prove inadequate to meet a constantly increasing world demand. The possibility of the aggregate world recovery's proving disappointing in its proportions is suggested by the spectacular decline of the southern oil fields of Mexico in 1922. There, production fell off from 16,873,000 barrels in January, 1922, to 8,117,000 barrels in December, 1922. Although this decline was in part made up by increases in the northern district, the total production from Mexican fields declined from 21,034,000 barrels in January, 1922, to 13,033,000 barrels in December, 1922.

It should be noted also that there has been a race on for some time among the leading nations for control of producing and possible producing areas. It now seems that the United States has fallen somewhat behind in the race and has been effectually barred from certain regions.[1] It may be that eventually we will be compelled to purchase our oil in the foreign markets. That, of course, in time of peace is not a matter of grave concern, provided the foreign markets are plentiful. There is nothing in the immediate situation, however, to occasion undue alarm, although it does justify a careful consideration of the source of our future supply and a review of the manner in which we have exploited our domestic reserves in the past.

Before launching into a discussion of this subject, however, it should be noted that underground porous rock

Survey thinks it a conservative estimate that the foreign reserve may yield as much as seventy billion barrels. See *Mechanical Engineering*, September, 1922, p. 567.

[1] Concerning the restrictions by which citizens of the United States are excluded from participation in the development of oil reserves in foreign countries, see Senate Document 272, 66th Congress, 2nd Session; Senate Document 11, 67th Congress, 1st Session; Senate Document 39, 67th Congress, 1st Session. See also Davenport and Cooke, *The Oil Trusts and Anglo-American Relations* (New York City, 1924).

formations saturated with petroleum are not our only domestic source of future oil supply. Field work conducted by the United States Geological Survey in 1913 and in succeeding years has called attention to vast bituminous shale deposits in Colorado, Utah, Wyoming and other States. This shale exists at or near the surface, and upon distillation much of it will yield between forty and fifty gallons of oil to the ton. Considerable experimental work has been done on these oil-shale deposits and at Elko, Nevada, a small-scale plant has been placed in operation. In Scotland where the oil-shales are rich in nitrogen, oil has been secured for some time as a commercial by-product in the recovery of nitrogen. Our domestic resources, however, have not yet yielded any appreciable amount of oil on a commercial basis. They, no doubt, can be relied upon to do so at some time in the future, but presumably large quantities of shale-oil will not be produced until economic pressure has been applied through a shortage of petroleum. Before oil-shale can be expected to meet any considerable portion of our demand for petroleum products, a vast engineering project must be carried through. Better methods of retorting and refining have yet to be worked out. Water supply and transportation afford problems yet to be solved. And with it all will come the shifting of a vast army of laborers into a new industry with the accompanying problems of housing, sanitation, etc. The whole problem is one of tremendous magnitude in the solution of which time is the most important factor.

Between this shift from a dependence upon natural petroleum for fuel, lubricants and motive power, and the creation of an available supply of shale-oil to meet the demands of industry, a period of economic stress may quite possibly intervene. A consideration of the possible methods of mitigating the severity of such a period is, therefore, of timely and practical concern.

The tremendous wastes which have accompanied the production of crude petroleum in the United States since

1850 are portrayed in a somewhat general, but none the less eloquent, manner in the following words of a British contemporary:[1]

The time . . . is coming, is, indeed well in sight, when the United States, partly through recklessly improvident exploitation and partly through natural processes of exhaustion, will be nearing the end of some of the available stocks of raw materials on which her industrial supremacy has been largely built. . . . The processes which have practically stripped Ireland of trees are operative in the United States over a far wider territory, on a yet more appalling scale, and in connection with many other sources of national wealth. The size and magnificence of the American inheritance and the rapidity and wantonness with which it has been squandered are an almost incredible commentary on human folly. On no country, perhaps, had 'affluent Fortune emptied all her horn,' in such varied and bountiful profusion, and no country could have shown itself more utterly ungrateful. The Americans have dealt with their resources, and deal with them to-day, in the pioneer spirit of sheer unmitigated pillage. . . .

America has recklessly and in sixty years run through a legacy, that, properly conserved, should have lasted her for at least a century and a half. . . . But the effects of fifty years of negligence and inefficiency are now becoming visible. Just when Americans have become accustomed to use twenty times as much oil per head as is used in Great Britain; just when invention has indefinitely expanded the need for oil in industry; just when it has grown to be as common and as true a saying that 'oil is King' as it was twenty years ago that steel was king; just when the point had been reached where oil controls money instead of money controlling oil — the United States finds her chief source of domestic supply beginning to dry up and a time approaching when instead of ruling the oil market of the world she will have to compete with other countries for her share of the crude product.

Nor have American spokesmen been less blind to the truth in this regard. The statement of a former official of the United States Fuel Administration rivals in eloquence and descriptive power that of his British contemporary.[2]

[1] Quoted by White, from E. Mackay Edgar, in *Sperling's Journal*, September, 1919, 'The Petroleum Resources of the World,' *Annals of the American Academy of Political and Social Science*, May, 1920, p. 132.

[2] Requa, M. L., *Exhaustion of the Petroleum Resources of the United States*. Senate Document, No. 363, 64th Congress, 1st Session, 1916, p. 5.

Our very prosperity makes us careless of the future; we feast and revel while the handwriting blazes on the wall in letters of fire, and we do not pay it even the cold compliment of a passing glance. As a nation, we are wasteful, apathetic, and forgetful. We waste our natural resources with shameful prodigality; we are apathetic of the future, and we forget that our reserves of natural wealth are by no means inexhaustible.

. . . . . .

We vaguely realize, if we condescend to think about it at all, that when such a time shall have arrived, in some distant generation, that centers of manufacturing must change and things generally undergo a radical realignment. . . .

Those of us who believe that posterity must settle these problems of heat, light, and power are living in a fool's paradise, and must inevitably awaken within the next few years to face, subdued and chastened, the real truth.

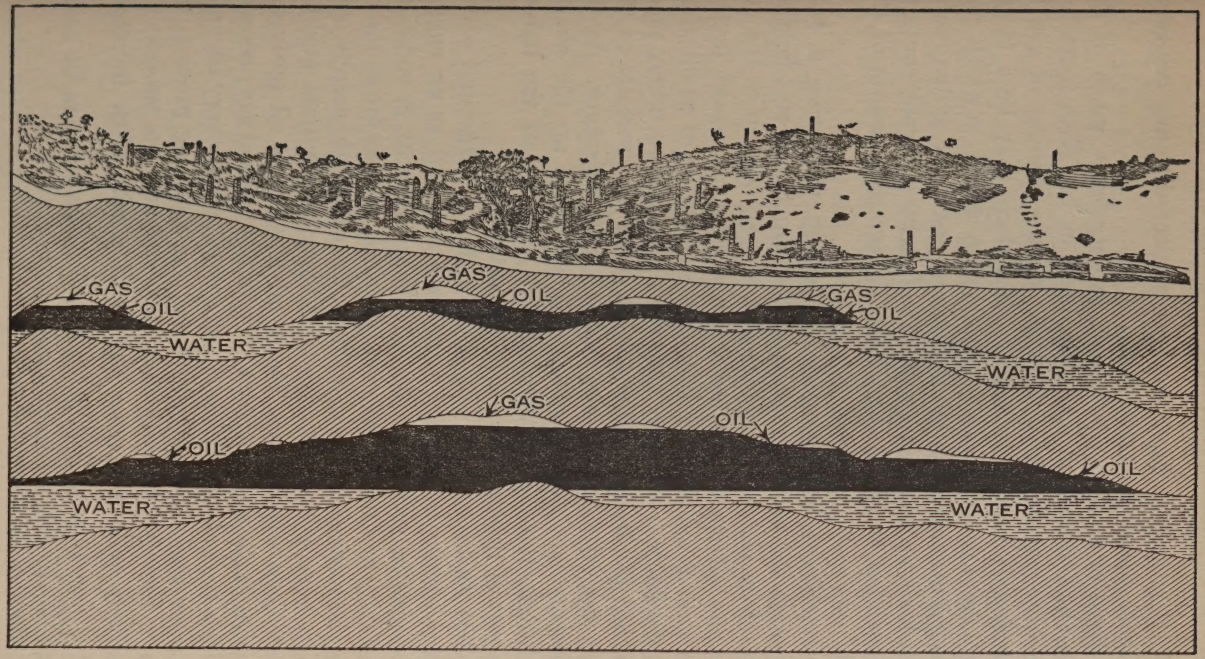
A consideration of these wastes referred to somewhat generally in the preceding quotations, to be of any practical account, necessitates a review of the methods of oil production. The first venture in oil production was a business enterprise with profit as a motive. It was a business success. Immediately thereafter oil production became highly competitive, the prospects of rich reward being of sufficient magnitude to attract thousands of speculators and investors into the field. Since the beginning of the industry until the present time oil production has remained, for the most part, highly competitive. As previously reviewed, a monopoly control was soon established in the transporting, refining, and distributing branches of the industry; but a monopoly of oil production has been impossible in the absence of legislation requiring it. Even with the application of modern methods of geology the exact location of an oil pool is a speculative affair. The uncertainty of the occurrence of petroleum, coupled with its migratory nature, has rendered a monopoly of oil production impossible. The same factors, coupled with the rich return afforded have made the industry highly competitive.

A consideration, therefore, of wastes in oil production is necessarily bound up with an inquiry into methods of

management under the competitive system, the end in view being to determine whether or not these wastes are incidental to the industry, and therefore avoidable with proper precaution, or whether they are inherent and abiding, a part of the system under which they manifest themselves.

Such a consideration, however, must necessarily be preceded by an inquiry into the nature of the underground occurrence of petroleum, the factors governing the manner of its accumulation, its disposal, and arrangement, and the mechanical process of its recovery. As pointed out in a previous paragraph, crude petroleum is formed from the remains of plant and animal life deposited in sedimentary or water-laid rocks, which have since been covered with later depositions, so that now oil is found at depths varying from a few hundred to several thousand feet. These strata were originally deposited horizontally and while they remain in this position are seldom capable of yielding oil in commercial quantities. Petroleum is nearly always associated with salt water and natural gas in the strata, which have been forced into undulations by the wrinkling or folding of the earth's crust. The fluid contents of the porous beds have obeyed the laws of gravitation, the oil, gas, and water distributing themselves according to their specific gravity. These fluids have migrated from their original source of deposition, the direction of migration being, in the main, upward along the beds of inclined strata. Migration has continued until prevented by an overlying impervious stratum, generally a bed of shale, which has acted as an effective seal, confining the fluids in their underground reservoir. Here they have distributed themselves in the pores or voids of the rocks, separating on a basis of specific gravity, the gas being found, for the most part, in the higher portions of the underground folds, the oil lower, and the water beneath the oil. (See Figure X.) Favorable regions for finding oil are areas that are underlain by sedimentary rocks consisting of a source rock, a reservoir rock, and a cap rock which have been gently or moderately

FIGURE X. VIEW OF THE OCCURRENCE AND MINING OF OIL AND GAS



(From photograph of model in the Division of Mineral Technology, United States Museum, Bulletin 102, vol. 1, pl. V.)

folded but which have not been subjected to any considerable degree of metamorphism.

Since natural gas is soluble in petroleum, much of the gas associated with oil is dissolved in it. With increased pressure, which varies with depth, the amount of gas in solution is further increased. But there may be a larger volume of gas than can be dissolved in the oil, in which case the gas occurs free in the higher portions of the underground reservoir, as set forth above. The free gas generally contains suspended in it, vapors of the lighter components of the oil.[1]

Petroleum is recovered by drilling or boring a hole through the earth's crust until the impervious seal holding the oil in restraint is punctured, the absorption of the gas by the oil thereupon becoming a very important factor. As soon as exploitation begins, the condition of equilibrium of the fluids is seriously disturbed, a migration taking place toward the point of abstraction under the pressure of the gas, the oil following the path of least resistance. As the pressure is thereby reduced the oil gives up the gas in solution, the latter carrying with it much of the lighter vapors of the petroleum constituents.[2]

The natural gas associated with the underground petroleum supply is valuable both as a fuel and as an energy resource in recovering the oil. When present in sufficient quantity and under sufficient pressure, the gas forces the oil to the surface in great volume, hundreds, thousands, and even hundreds of thousands of barrels sometimes gushing forth in a single day. The total amount of oil recovered varies, in the main, with the amount of utilized gas pressure. When the pressure has been exhausted, oil recovery becomes a more expensive enterprise under a pumping process, the daily recovery being greatly lessened and the process extending over a greater period of time. With increased

[1] Lewis, J. O., *Methods for Increasing the Recovery from Oil Sands*, Bulletin 148 (U.S. Bureau of Mines, 1917), pp. 11–13.

[2] *Ibid.*, p. 13.

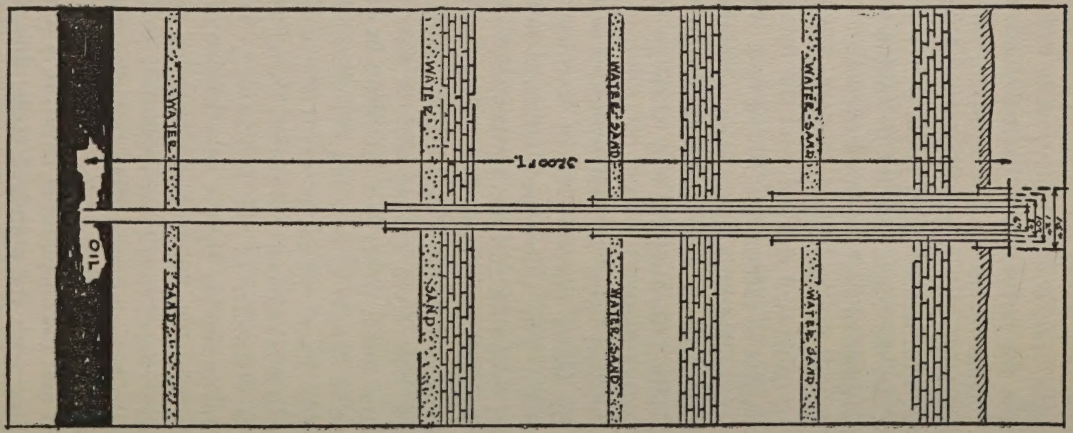
depths, too, pumping becomes very much more expensive and in some localities, where the depth is very great, it may not be profitable and, consequently, wells are sometimes abandoned when the natural flow has subsided. The problem of gas conservation and utilization, is, therefore, necessarily bound up with a consideration of waste in oil production and will, accordingly, come in for further discussion below. In the meantime let us take a look at the mechanical processes of petroleum extraction.

In drilling for oil two principal methods are employed, the standard or cable-tool method, and the rotary process. The former consists in alternately lifting and dropping the cutting tool, suspended by a cable from a wooden derrick, the weight of the tool pulverizing the encountered formations and literally punching its way through the earth's crust to the desired depth.

The hole is drilled 'wet,' at first by water pumped into it and later by water encountered at varying depths as drilling proceeds. The pulverized cuttings are removed with the water, from time to time, by means of a bailer with a dart valve lowered by a steel line. As greater depth is attained it becomes necessary to set iron piping or casing to prevent the hole from caving and to shut off water horizons because much water is a handicap in drilling. In addition, there is danger of flooding the oil sand should it be encountered. From whatever point the casing is set, the size of the hole is reduced and varies, therefore, with the depth and the character of the formations. It does not taper, but is made smaller by the substitution of a smaller cutting tool or bit. The hole when completed resembles a telescope, each string of casing corresponding to a reduction in the size of the hole and extending from the surface to its seating. (See Figure XI.)

In very soft and unconsolidated rocks, it is impossible to carry on drilling with the standard tools, due to constant caving of the walls of the hole. In such localities the hydraulic rotary system is used. The following brief descrip-

FIGURE XI. SKETCH SHOWING HOW A WELL IS CASED TO PREVENT CAVING OF THE HOLE, AND TO SHUT OFF WATER HORIZONS



With each successive string of casing the size of the hole is reduced, the well when completed resembling a telescope. In the Ranger, Texas, field where wells are drilled over 3200 feet, the hole is begun with a diameter of about fifteen inches and completed with a diameter of about five inches.

tion of this process is taken from L. C. Snider, *Oil and Gas in the Mid-Continent Fields:* [1]

> Drilling is accomplished by a bit at the end of a drilling stem, which is composed of lengths of pipe screwed together. The top length of pipe is square, the remainder is round. . . .
>
> The drilling stem and bit is rotated by means of a rotary mechanism. It consists simply of a rotating table centered over the hole and driven by a chain drive. The square section of the drill stem is clamped into the rotary.
>
> The walls of the hole are kept from caving by means of circulating mud, which is forced by pumps through a swivel at the top of the drill stem, and back on the outside of the stem. The circulating mud 'plasters up' the walls of the hole so that they will stand while the drilling stem is being removed and the casing set.

Oil production is unique in at least one important respect among mineral recovery processes. While the initial expense in such an enterprise is great, the expense connected with prolonged exploitation is practically negligible.[2] It takes a considerable outlay of money to finance the drilling of an oil well, but once it is completed and oil is discovered in its natural association with gas, a kind nature furnishes the lifting power, delivering the crude product, sometimes in prodigious quantities, to the earth's surface. A growing demand for petroleum products, the possibilities of rich reward, and a gambling spirit, have been a sufficient urge to guarantee a prolonged and continued search for new and undiscovered fields.

The location of the first well was determined by the presence of oil seepages at the earth's surface. Since that time, chance has played the greatest rôle in oil exploitation. The willingness on the part of the investors to stake their all in a 'wildcat' search for oil, and their hopes of enormous reward, have accounted for the discovery and development of new producing areas. This was entirely true in the early

[1] Snider, L. C., *Oil and Gas in the Mid-Continent Fields* (Oklahoma City, 1920), p. 54.

[2] This statement applies primarily to wells during the time of their natural flow. The pumping process is more expensive.

history of the industry. Of recent years application of geological principles in the search for and development of oil-producing properties has eliminated to a considerable extent the element of chance. By a careful mapping of surface structure it is possible to determine with encouraging precision the most favorable localities for the accumulation of petroleum. As development progresses, well-kept drilling records afford an additional source of information, which, coupled with surface measurements, furnish a tridimensional knowledge of the geologic conditions that is remarkable for its completeness and accuracy. Thus, by the application of modern engineering methods oil production may be lifted from the realm of pure chance and made to approach a scientific exactitude. While geology has made a remarkable contribution to the oil industry, it still remains true that only by the drill can the underground accumulation of oil be definitely determined. The president of one of the large Mid-Continent producing companies, however, is said to have calculated from extensive records of his company that 85 per cent of the wells located on the basis of careful geological surveys proved to be productive, whereas only 5 per cent of the wells located at random were successful.[1] Most modern oil-producing companies have recognized the significance of this calculation and no longer place their reliance in a blind, if earnest, search for petroleum-producing areas. On the contrary, many companies have as a permanent branch of their organization a geological department, composed of a staff of skilled geologists. It is on the efforts of these trained experts that we must henceforth largely depend for the opening of new producing territories. But in view of the tremendous shrinkage which our domestic reserves have already undergone and the limited extent of possible production areas, it seems not unlikely that their active efforts, in so far as this country is concerned, may in the not far distant future prove insufficient to meet the encroaching demands upon the

[1] Pogue, J. E., *op. cit.*, p. 343.

industry. What is of equal importance with the discovery of new fields is the more economical exploitation of both old and new. It is in this regard that a competitive management breaks down. Competition in oil production inevitably means waste. Not only may it mean a lessened oil recovery, but it frequently results in a greatly increased cost per quantity unit of oil produced. This thesis will be discussed under six topics: (1) Waste by duplication; (2) Waste of gas pressure; (3) Waste of gas as fuel; (4) Waste of natural-gas gasoline; (5) Waste by flooding oil sands; and (6) Guarding technological information.

CHAPTER VIII

THE PRODUCTION OF PETROLEUM WASTE BY DUPLICATION

An oil pool is a geologic unit. As soon as the drill punctures the restraining rock formation, the oil, which is of a migratory nature, actuated by the gas pressure and following the path of least resistance, begins its flow to the earth's surface.[1] Theoretically, under the competitive system founded upon the basis of private ownership, the underground oil belongs to the person under whose property it happens to be found, the mineral rights being vested in the owner of the land. In practice, the right of exploitation is delegated to an oil-producing company upon a royalty basis,[2] the owner of the land usually receiving one eighth of the oil produced, the balance going to the producing company. Obviously, however, the relationship between arbitrary lines on the surface and the underlying geologic unit (the oil pool) is an artificial one. Since oil is migratory and will travel underground it is essentially no man's oil until it is brought to the surface. According to current custom, it then belongs to the company through whose well it issues, subject to agreement with the property owner. Such an arrangement leads to spacing of wells with a regard chiefly to quick profit on the part of the producer, not with a regard to the economical recovery of the available underground supply. Oil production, under the competitive system, is of necessity conducted on the principle of robbery, the aim of each producer being to drain the largest possible underground area in the shortest length of time, be-

[1] Gas furnishes the chief natural source of energy for the expulsion of oil. In some fields, however, the oil is forced out under hydrostatic pressure.

[2] The mineral rights are generally leased for a cash consideration plus a royalty on all oil produced.

fore the oil is secured by a competitor. A glance at Figures XII, XIII, XIV (see pages 147, 151, 156) will make clearer the significance of this statement. It has been an almost universal practice to locate the first well drilled on a tract close to a property line, with little regard for geologic conditions, but with the idea of draining as much of an adjoining tract, and thereby securing as great an amount of the competitor's oil, as possible. Viewed from a different angle, it might be said that the purpose is to prevent a competitor from draining the oil from under the initiator's tract — a clear case of an offensive defense being both expedient and desirable.

Note on the maps the tendency for wells to follow property lines in pairs, one on each side, as a result of the application of this principle. So well established has this tendency become that, in the absence of a willingness on the part of a producer to drill an offset well, the law [1] may step in and compel the operator to do so, in order that the owner's rights to a share in the underground resource may be protected.

A cursory glance at the matter would seem to indicate that the logical unit for exploitation would be the geologic unit — the oil pool. A more deliberate study of the matter can lead to no other conclusion. Hypothetically, let us substitute for unrestricted competition some form of unified control, and for the end, profit, let us substitute oil production; the matter of spacing wells immediately becomes a scientific consideration. Under such conditions, after a pool had been discovered, the location and spacing of wells would be a matter of careful study with especial attention to surface structure as indicative of the position and arrangement of the underground oil, gas, and water. Local geological conditions would be the determining factors. These would vary, obviously, in different localities, but in all cases the aim would be to place wells in such a position with regard to the dip of the strata and the position of the

[1] A common law principle.

gas in the higher portions of the folds, as to guarantee the fullest possible utilization of gas pressure in oil recovery. An effort would be made to avoid as far as possible drilling into the water which is usually found in the same stratum with the oil in the lower portions of the folds. As development progressed the location of additional wells would be determined by a careful study of well records, with particular attention to the direction and extent of the dip of the producing horizon, the production behavior of completed wells, the texture and porosity of the producing formation, and the probable drainage area of each well. Property lines would thereby become entirely irrelevant and beside the point.

In this regard it should be noted that the proper spacing of wells to ensure an economical recovery of the underground oil is an extremely complex matter. It will be recalled that petroleum is generally found associated with natural gas. Under pressure the oil will have absorbed a portion of the gas, the amount of pressure determining the amount of gas in solution. This gas, which is compressed and dissolved in or associated with the oil, is the chief force in expelling the oil from the underground formation. When the drill punctures the restraining stratum and exploitation begins, the oil and gas migrate toward the opening. The frictional resistance to gas being less than to oil, the former will move more rapidly than the latter. As the pressure is released there is a constant tendency for some of the gas to be dissociated from the oil which tends to remain behind. The gas pressure becomes exhausted long before all the oil has been recovered. The percentage of oil remaining underground will differ with varying conditions in different regions and in different portions of a common area. Some factors affecting the portion recovered are the porosity and texture of the sand, the viscosity of the oil, the available energy, and the efficiency with which it is utilized. Estimates of unrecovered oil range from 40 to 90 per cent. Mr. J. O. Lewis, one of the best informed men in the

industry on this subject, estimates that under current methods of recovery perhaps from 80 to 90 per cent of the total petroleum remains underground.[1] The problem of maximum petroleum production in any given area is largely a problem of efficiency in the utilization of gas pressure.

The tendency for the oil to lag behind the gas in its movement toward the outlet varies with the distance which the oil and gas move; the greater the distance, other factors being equal, the larger the percentage of oil that will remain underground. In the words of Messrs. Beal and Lewis: 'One well in the course of time may drain out all the gas from the sand as completely as a hundred wells, yet the amount of oil drained from the sand will be far less than if the hundred wells had been drilled.'[2]

A close drilling programme if wisely carried out will tend to increase the efficiency of the oil recovery processes. If wells are placed relatively close together and drilled simultaneously before the gas pressure has been exhausted, the ultimate recovery will be relatively great. Such a drilling programme will result in a large initial production, but the decline will be rapid because the gas will become exhausted more quickly due to the greater number of holes through which it escapes. With a close and rapidly executed drilling programme, the ultimate per-acre recovery will be somewhat larger, but the per-well recovery will be smaller than if the wells had been more widely scattered. With widely scattered wells, the drainage area per well will be correspondingly increased and a larger volume of gas, hence a larger volume of oil, will find outlet through each well. With a scattered drilling programme the wells may be expected to have high initial production, their decline will be relatively slow and their ultimate recovery will be large. It has been found that the recovery per well in the Hewitt,

[1] Lewis, J. O., *Methods for Increasing the Recovery from Oil Sands*, Bureau of Mines, Bulletin 148 (Washington, 1917), p. 28.

[2] Beal, C. H., and Lewis, J. O., *Some Principles Governing the Production of Oil Wells*, Bureau of Mines, 1921, p. 27.

Oklahoma, field has been twice as great where one well was drilled to every ten acres as where four wells were drilled to every ten acres. But it has also been noted that the ultimate recovery from ten acres was almost twice greater when a tract was drained by four wells instead of by one.[1]

In the Nowata district, Oklahoma, three wells each with an initial production of 6000 barrels, producing under substantially similar conditions aside from their spacing, had drainage areas of ten acres, eight acres, and 6.3 acres, respectively. Their ultimate recovery was 16,900 barrels, 15,200 barrels, and 14,300 barrels, respectively. Their per-acreage yields, however, were 1690 barrels, 1900 barrels, and 2386 barrels.[2] On a large tract in the Osage field, eighteen wells spaced over one thousand feet apart showed an average daily production for the first year of 328 barrels. Fourteen wells 660 feet apart producing under substantially identical conditions save from the matter of spacing, showed an average daily production throughout the first year of only 246 barrels.[3] Other similar illustrations might be given. It is a well-established fact, however, that early wells in isolated positions will undergo a slow rate of decline and will ultimately yield a larger volume of oil than would the same number of wells under similar conditions if more closely spaced. The per-acreage yield, however, would be smaller in the first instance than in the second. Efficiency in oil production, it seems, demands a close spacing of wells. But oil production is an expensive enterprise. The initial cost for equipment and drilling when the depth is great runs into the tens of thousands of dollars per well. Hence, economy of operation cannot be sacrificed entirely to effi-

[1] Swigert, T. E. and Schwarzenbek, F. X., *Petroleum Engineering in the Hewitt Oil Field, Oklahoma*, Coöperative Bulletin, U.S. Bureau of Mines and Ardmore, Oklahoma, Chamber of Commerce (January, 1921).

[2] Cutter, W. W. and Clute, W. S., 'Relation of Drilling Campaign to Income from Oil Properties,' *Reports of Investigations*, Bureau of Mines, Serial No. 2270.

[3] *Idem.*

ciency in operation. A balance must be struck whereby the cost of recovery is not excessive with respect to the value of the oil recovered. A few more wells may yield a few more hundred barrels of oil per acre, but under the price system it would be inadvisable to drill the additional wells if the oil recovered through them were insufficient to replace the capital expended and yield a normal rate of return on it. The characteristics of an economical drilling programme are variable. They change from time to time and from place to place. Three factors of importance in determining a spacing programme which will combine efficiency with economy are the price of petroleum, the cost of drilling, and the possible ultimate recovery from the field. The last will tend to vary with the numerous geologic factors which influence oil production. Spacing of wells, economical for one pool, may not be economical for another pool.[1]

While these above considerations are all very important from the viewpoint of economically recovering as much of the underground petroleum supply as possible, they have been given little attention in the past.

Practically, the unit of exploitation is the property tract, control over which is secured on a basis of private ownership and competitive leasing. The result has been that the number of wells drilled in a given area and their location have depended largely upon the number of boundary lines and the size of the tract — the smaller the size the greater the number of wells per unit of area. (See Figure XIII.) The time element becomes the matter of prime importance, the small holding necessitating a competitive race in oil extraction with duplication and waste everywhere. The results have frequently been a multiplication of wells far

[1] Tight and irregular sands are not affected so materially by scattered or offset drillings, and there are unusual instances in the Gulf Salt Dome fields where wells only one hundred feet away from producing wells are 'brought in' with initial productions equal to or greater than that of isolated wells without effecting a decline in near-by wells. On the other hand, wells in the Ranger, Texas, field when drilled close to producing wells generally proved commercial failures.

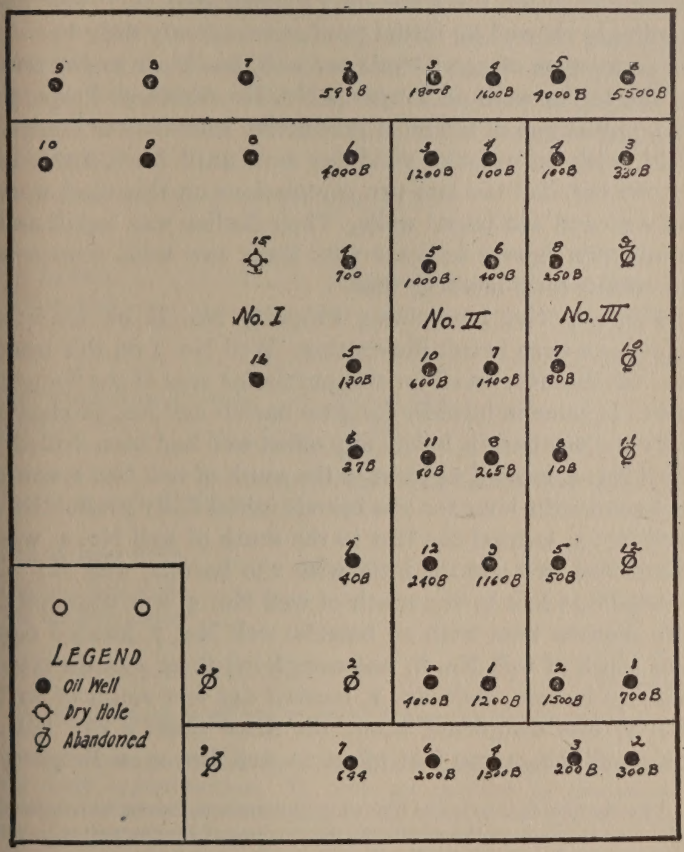
beyond the number necessary to effect an economical drainage of a given area. This excess of wells has resulted in greatly increasing the cost of oil production, and in some cases, no doubt, has lessened the total recovery. Often additional wells have not only been unnecessary from the broader economic standpoint, but have represented a net loss to the operators. A somewhat detailed survey of the production records of certain typical tracts in the Ranger field of Texas will make these points clearer.

Well-production records in the older portions of the Mid-Continent field indicate that the average life of wells is from six to eight years. The first year the decline is somewhat rapid, but it settles in the second year, the curve having a tendency to flatten out thereafter over a period of several years.[1] The Ranger field was discovered in the fall of 1917 and was heralded as a boon to the oil industry. The first wells drilled came in with large initial productions. An optimistic oil world assumed that their decline curves would follow those of the older portions of the Mid-Continent field, and that the production would extend over a period of six or eight years. The large initial production indicated enormous profits. A tremendous drilling campaign ensued. The spacing of wells depended somewhat upon the size of the tracts, but the customary distance between wells was about 500 or 600 feet, this distance having yielded a profit for the most part in the older portions of the Mid-Continent field. The results, however, have not been satisfactory from either the business or the broader economic point of view, even to those concerns first to complete their drilling campaign. While the initial production of many of the wells in this field was very large, the decline in gas pressure was phenomenally rapid. Additional wells have come in for much smaller production, have declined very rapidly and have frequently been operated at a loss.

[1] Beal, C. H., *The Decline and Ultimate Production of Oil Wells*, Bulletin 177, Bureau of Mines, p. 65, Figure 16.

A study of the properties on the accompanying plot serves to illustrate this point. (Figure XII.) Property No. II con-

FIGURE XII. A PORTION OF THE RANGER, TEXAS, OIL FIELD, SHOWING THE INITIAL PRODUCTION OF THE WELLS DRILLED ON THESE PROPERTIES AND THE EFFECTS OF A DELAYED DRILLING PROGRAMME — THE SMALLER WELLS IN ALMOST EVERY INSTANCE WERE DRILLED SUBSEQUENT TO THEIR OFFSETS



sisting of 75 acres, had a total of 12 wells drilled on it. The drilling campaign was a rapid one and with the exception of well No. 3 in the northwest corner of the tract all

of the wells on this farm were completed from one to nine months ahead of their offsets. Accordingly, the first 11 completions showed an initial daily production of 10,405 barrels, or an average of 946 barrels per well.[1] The 15 offsetting wells, with the exception of well No. 1 on Property No. I which preceded its offset on Property No. II, were completed after the wells on Property No. II. They accordingly showed an initial production of only 6617 barrels or an average of 440 barrels per well, less than 50 per cent of the earlier wells on Property No. II. Although Property No. II was one of the most productive leases in the Ranger field, with an average yield per acre until May, 1920, of 12,000 barrels,[2] the last two completions on this tract were only 40 and 240 barrel wells. Their decline was rapid, and production figures indicate that these two wells represent an almost total financial loss.

Property No. I adjoining Property No. II on the left, affords an even better illustration. Well No. 1 on this tract was the discovery well for this particular area of the Ranger field. It came in initially for 4000 barrels and had produced over 200,000 barrels before any offset well had been drilled.[3] Well No. 4, located 645 feet to the south of well No. 1, came in five months later for 700 barrels initial daily production; well No. 5, located 645 feet to the south of well No. 4, was completed two months later with 130 barrels; well No. 6, located 645 feet to the south of well No. 5, was completed two months later with 27 barrels; well No. 7, located 645 feet south of well No. 6, was completed three months later with 40 barrels; well No. 2, located 645 feet south of well No. 7, was completed about the same time, a dry hole. This well was a 500-foot offset to well No. 2 on Property

[1] Production figures in the following illustrations, except when special reference is given to the contrary, were collected by the writer in the field and are based on pipe-line runs.

[2] Stephenson and Bennett, 'Decline and Production of the Ranger Field,' paper read by Stephenson before the American Association of Petroleum Geologists, Dallas, Texas, 1920.

[3] *Idem.*

No. I which was initially good for 4000 barrels, but which had flowed for over nine months and had evidently robbed the surrounding territory of its gas pressure. Altogether there were 18 wells completed on Property I, from which there had been produced by May, 1920, 482,000 barrels of oil. Of this amount the first well drilled produced 422,000 barrels. The remaining 17 wells, including three dry holes due to late completions and close spacings, produced 60,000 barrels. E. A. Stephenson, formerly chief geologist for the New Domain Oil and Gas Company, on a basis of the production data for this lease, made the following calculations:[1]

Production well No. 1.....	422,000 bbls.	
Royalty.....	52,750	
Net barrels.....	369,250 @ $2.25 per bbl.	$832,000
Cost of well		40,000
Profit.....		$792,000
Production from 17 wells.....	60,000 bbls.	
Royalty.....	7,500	
Net barrels.....	52,500 @ $2.50 per bbl.	$131,250
Cost of 17 wells @ $40,000.....		680,000
Loss on later wells.....		$548,750
Profit on first well.....		$792,000
Loss on later wells.....		548,750
Net profit.....		$243,250

A consideration of ten typical leases in the Ranger field

[1] Stephenson and Bennett, *op. cit.* These calculations are obviously only rough approximations. No costs are included for the acreage leased or for operations subsequent to well completions. On the other hand, the future production which may be secured under a pumping process is not calculated. Regarding the possibilities in this regard, Stephenson and Bennett make the following statement: 'The small amount of data which has been secured suggests no great recovery or lengthening of the life of the wells in the Ranger field proper by present methods of pumping.'

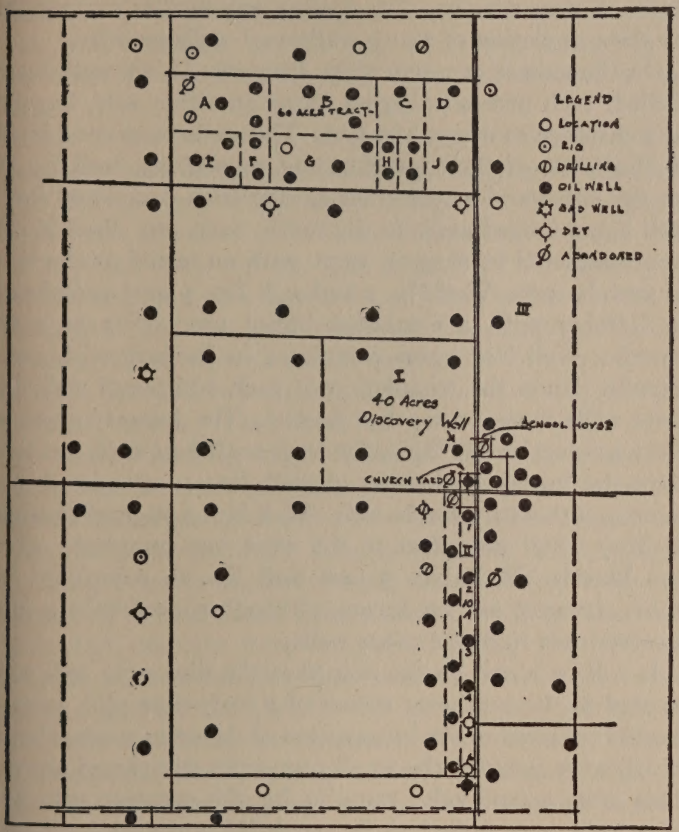
showed that the first wells drilled produced from 38 per cent to 88 per cent of all the oil produced on the respective tracts, the average percentage by first wells being approximately 68 per cent. The number of wells drilled on the properties considered varied from two to eighteen, and in most cases where a drilling campaign approached completion the later wells drilled represented a loss to the operator, in some instances the loss being sufficiently great to offset a considerable portion of the large profit secured from the first wells.[1]

The properties under consideration in the foregoing discussion have been comparatively large, ranging in size from 45 to 220 acres. Accordingly, they came in for much less intensive exploitation than smaller tracts would have. Figure XIII illustrates the important rôle chance plays in determining the manner in which an area is exploited. The properties on this map lie adjacent to rural cross-roads at the intersection of which were located a school house, a churchyard, and a cemetery. Oil was originally discovered on the east side of the present Ranger field and as development spread westward the lease value of the land rose enormously. Tracts which were originally leased for as little as fifty cents per acre were later released for several thousand dollars; a forty-acre tract, after the completion of a well, having been reported to have sold for $1,000,000. In the scramble of competition with reckless bidding on the part of speculators, it became very much to the interest of property owners and lease holders to block their holdings into small tracts for leasing purposes. In making surveys a number of mistakes were made with the result that there were several narrow strips left over, which were leased to competing companies.

The first well completed in this area was well No. 1, on Property I, as shown on the accompanying chart. It was finished on June 6, 1919, with an initial production of 7000 barrels. Before any offset well had been drilled, this

[1] Stephenson and Bennett, *op. cit.*

FIGURE XIII. MAP SHOWING A PORTION OF THE RANGER, TEXAS, OIL FIELD, ILLUSTRATING HOW THE LOCATION OF WELLS IS DETERMINED BY PROPERTY LINES — THE SMALLER THE TRACT THE GREATER THE NUMBER OF WELLS PER UNIT OF AREA



This manner of exploitation is the logical result of the competitive system. Oil being a migratory mineral has no respect for property lines, and a well on one tract may drain the oil from under the tract of a neighbor. This leads to a competitive race in oil extraction which frequently proves uneconomical.

well had produced 300,000 barrels of oil.[1] Immediately after its completion an exciting drilling campaign ensued, the small excess strips, the school yard, and the church lot

[1] Stephenson and Bennett, *op. cit.*

coming in for intensive exploitation. The first offset well was located about 100 feet from the discovery well, and after the completion of the second well the discovery well declined very rapidly. The decline was further augmented by the completion of many additional wells near by.

On the narrow ten-acre strip, Property II, six wells were drilled, each necessitating an offset on either side, located at a distance of about 150 feet. The wells were completed in the order of their location and numbering, well No. 1 on the north end of the tract having been completed first, well No. 2 immediately to the south, next, etc. Well No. 1 was completed in August, 1919, with an initial production of 5000 barrels. Well No. 2 and well No. 3 were completed in October with a combined initial production of 5300 barrels. Well No. 4 was completed in January with 1200 barrels. Upon the completion of each additional well the prior wells showed a marked decline. The January average daily production for the entire lease with four wells was less than the initial production of well No. 4, completed the same month with 1200 barrels. Well No. 4 stopped flowing in May when the offset to the west was completed with 200 barrels. Well No. 5 and well No. 6, completed in February were not producers, although spaced only a few hundred feet from the other wells.

It will be noted on the map that the discovery well was located in the southeast corner of a forty-acre plot, immediately adjacent to the intersection of the cross-roads, about which were grouped the small properties mentioned above. This area, accordingly, came in for the greatest activity. Five wells were drilled on Property III, grouped as closely around the school yard as they might well be, the distance between derricks being about 100 feet. The last one of these five wells on Property III was completed for only 75 barrels, and soon ceased to flow. On May 1, 1920, the well on the school lot had not yet been finished, having met with a number of accidents in drilling. It was owned by a small stock company, whose drilling contract called for the

completion of a certain stated depth. It was entirely surrounded by other wells which had already ceased to flow, and there was no chance of its becoming a producer. This fact was quite obvious to the driller in charge with whom the writer talked, yet it was necessary, according to contract, to complete the well which represented a total loss.

The sixty-acre plot to the north was divided for drilling purposes into eleven smaller tracts ranging in size from two and one half to ten acres (Properties A–J inclusive). From one to three wells were completed on each plot, twenty-four wells having been located on the sixty acres. Complete production figures for all these properties are not available. The first well, however, was completed in September, 1919, with an initial production of 5000 barrels. Within the next two months five wells were completed on different tracts. They were all good wells, their initial production totalling 16,700 barrels. The next seven wells completed several weeks later were very much smaller with a total initial production of 4500 barrels. In no instance did they increase the daily lease production, the properties showing a steady decline, despite the additional wells completed. The production figures on two wells are not available, but the last five, completed during February and March, were all failures, their combined initial production being less than 100 barrels. On May 1, one well had not yet been completed, but apparently had no chance of being a producer. Three locations were abandoned after the derricks had been finished because later wells had come in with a very low production.

The illustrations given above serve to indicate the extent of waste through duplication, which a competitive race in oil extraction may occasion. Late wells drilled in the Ranger field resulted almost uniformly in loss to the operator. The extent of loss varied roughly with the distance between wells and the delay in the drilling programme. The drilling programme described and illustrated above was

neither economical nor efficient. Theoretically, the greater the number of wells that are drilled within a given area, the greater the ultimate recovery of oil per acre. But the time at which the holes are drilled is of equal importance in effecting complete extraction of oil as is the number of holes drilled. In the above described section of the Ranger field (see Figure XIII) many of the wells were drilled after the gas was almost completely exhausted, and hence did not assist to any marked extent in effecting a more complete extraction of the oil. An unsynchronized drilling programme lessened the possible recovery. On theoretical grounds it seems probable that improper spacing of the wells which were drilled led to the same result. The school lot, the church lot, and excess surveys happened to be near the discovery well and accordingly came in for quick and intense drilling. The wells were bunched in a very small area, consequently additional wells did not increase to any marked extent the area which would have been drained by the first well alone. In other words, they did not lessen materially the distance which the oil had to travel to find an outlet, but they increased greatly the rate at which the gas escaped. They no doubt secured a higher per-acreage recovery from the more immediate area involved than one well would have done, but they accomplished this at the expense of a smaller per-acreage yield from the more remote areas. 'Too close spacing is detrimental to the field as a whole, since the gas pressure falls off and its sustaining influence is lost to neighboring operators who might otherwise benefit from securing sustained production while their long drilling programmes were in progress.' [1]

While the decline in production at the Ranger field was unusually rapid, the field has been more conservatively drilled as regards the actual number of wells put down than have a great many other oil-producing regions. The Burkburnett, Texas, field offers perhaps a more conspicuous example of uneconomical oil production. Oil was discovered

[1] Cutler, W. W., and Clute, W. S., *op. cit.*

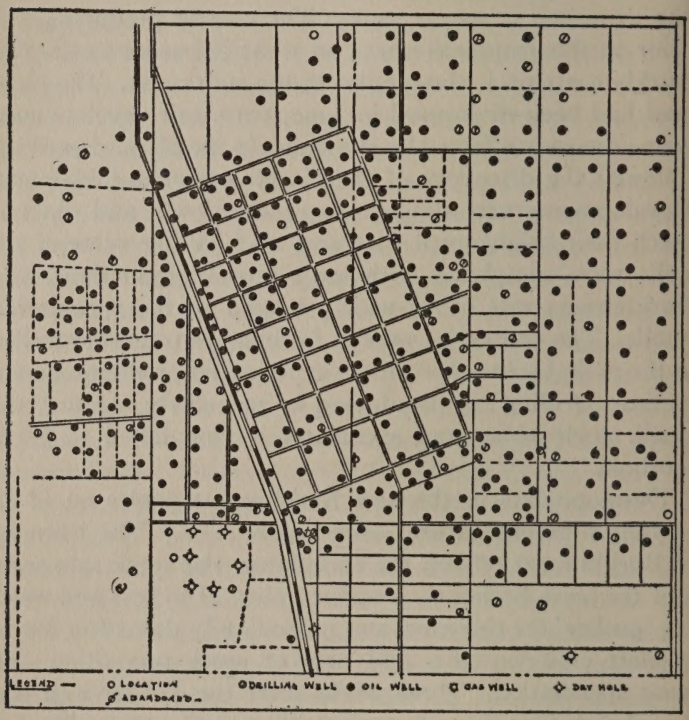
on the Fowler farm on the northern edge of the townsite of Burkburnett during the last week of July, 1918. The completion of this well, with an initial production of 2200 barrels, marked the signal for one of the most highly speculative and exciting drilling campaigns which the oil industry has witnessed in recent years. The nearest producing well prior to this completion was on what is known as the Old Burkburnett pool, three miles to the southwest. The older pool had been discovered in June, 1912, but developments were adversely affected by the slump in the oil market which followed the discovery of the Cushing pool in Oklahoma. Developments accordingly progressed slowly and did not reach their height until 1917 and 1918. While some of the wells were completed with large initial productions, Old Burkburnett was never widely known to the speculating public. The properties were in fairly large tracts controlled in the main by the older, more experienced production companies. Drilling was conducted in an orderly manner, the small stock-jobber and speculator having failed to get a foothold.

Developments in the new Burkburnett pool were of an entirely different nature. (See Figure XIV.) The townsite of Burkburnett offered the speculator, the stock salesman, and the lease broker their opportunity. The first well was a big 'gusher' for this area, and immediately thereafter Burkburnett experienced a wild orgy of stock promotion and lease speculation. Three weeks after the Fowler well was completed, fifty-six wells were drilling on the town site, and locations had been made by the hundreds.[1] Town lots were sold for enormous prices and drilling for oil became anybody's business. Tracts adjoining the townsite were divided into acre and half-acre plots and in some instances mere drilling sites were sold. Drilling continued apace. By

[1] For a more detailed account of developments in Burkburnett field, see 'Engineer's Survey of Burkburnett,' a report of a study conducted by the Bureau of Mines, and published in five weekly installments in the *Oil and Gas Journal*, beginning March 24, 1922.

the spring of 1920 the productive limits of the townsite pool had been determined. By this date a total of 885 wells had been drilled on a proven area of 1265 acres, an

FIGURE XIV. MAP OF A SECTION OF THE BURKBURNETT, TEXAS, OIL POOL



This pool was located on the townsite of Burkburnett, and accordingly offered an opportunity for the 'little man' with a reserve of initiative but a limited supply of capital, each town lot affording a potential drilling site for one or more wells. It is estimated by the operators themselves that three times as many wells were drilled in this pool as were needed to economically extract the oil. The result was a tremendous waste of labor and material.

average of 1.4 acres per well; and drilling on the townsite proper averaged slightly less than one acre per well.

During the progress of developments at Burkburnett 'wildcatting' was carried on extensively in the surrounding area. About the middle of April, 1919, a 'wildcat' was

'brought in' with an initial production of 2000 barrels per day. This well was completed by the Ryan Petroleum Company on the R. M. Waggoner farm, three and a half miles northwest of the townsite pool. The frenzied activities which had characterized developments in Burkburnett were repeated in this section. While there were no town lots here, many properties were divided into one- two- and three-acre tracts and it was not uncommon to drill four wells on a five-acre tract. When intensive operations began in this section one of the large pipe-line companies issued a notice that continued active drilling would inevitably result in more oil being brought to the surface than could be handled with available storage and transportation facilities. Under the urge of competitive endeavor, however, it was difficult to restrain operations. The migratory nature of oil rendered speed imperative and caution was thrown to the winds. Indeed, wastage of oil was a boon to the stock promoters and lease salesmen, for a big flow of oil over the landscape was excellent advertising and increased the ease with which new stock could be placed on the market. As a result of these conditions available storage was soon filled and when storage failed the oil was wasted onto the ground or turned into Red River. By the end of June, 1920, there had been 1251 wells drilled on a proven area of 2440 acres, an average of one well to every 1.8 acres. By September, 1920, a total of 2136 producing wells and 226 dry holes had been drilled on the Burkburnett townsite and the Northwest Extension pools.

It is the opinion among oil men and petroleum engineers familiar with conditions in these pools that the drilling programme as executed was extremely uneconomical. Mr. R. E. Collom, who conducted the study of the Burkburnett field, sponsored by the Bureau of Mines, issued the following word of warning to operators in the recently opened Huntington Beach, California, field, also a town-lot pool, regarding the spacing programme on the Burkburnett townsite: 'It is probable that a normal development programme

for this pool, considering depths of holes, would be one well to every five acres. In other words, 250 wells, or one third of the number actually drilled, should have been sufficient to economically drain the pool.'[1] Mr. Collom suggests that one well to five acres in the Townsite and Extension pools would have been a normal programme for oil men to have followed. He says:[2]

> Even with one well to five acres there will be interference. Each well, and its future behavior, becomes affected by its neighbors. As the gas pressure, which drives the oil into the well, drops, production of old wells declines. Gushers stop flowing and are put to pumping. Presently there is not sufficient pressure to force oil into the hole and vacuums are placed on the wells. Close drilling aggravates all these conditions. In June, 1920, the fluid level had dropped so low in Burkburnett Townsite pool that oil would only rise, in the hole, half way up through the sand. Because of close drilling and marked interference of wells, the production history of Burkburnett Townsite and Northwest Extension is practically a duplicate of the production history of any oil well of either pool. The result of this interference was that in the Burkburnett Townsite pool, for example, within six months after the discovery well was drilled, the average initial production had dropped to 300 barrels in the first twenty-four hours, and in July, 1919, in this same field, which a year previous had boasted 2000-barrel gushers, the average initial production of new wells was thirty-eight barrels per day.

Messrs. H. N. Bell and J. B. Kerr in presenting the results of the Bureau of Mines' study of the development programme as executed in these pools state: 'The two pools could have been developed economically with 830 wells, which would have been spaced close enough to drain in a satisfactory manner the 4175 acres of land. These wells at $21,000 each would have cost $17,430,000 as compared to $43,407,000 for those actually drilled.'[3]

[1] Collom, R. E., 'Spacing of Wells and Town-Lot Development,' *Summary of Operations, California Oil Fields*, January, 1921.

[2] *Ibid.*, p. 11.

[3] *Oil and Gas Journal*, March 31, 1922, p. 96. It should be noted that the Texas State Railroad Commission has attempted to prevent excessive over-drilling under powers granted it by legislation of June 18, 1919. The Commission ruled on July 26, 1919, that no well shall be drilled nearer than 300 feet to any other completed or drilling well

Thus far the illustrative material has been drawn largely from the North Central Texas fields. It should not be presumed, however, that the State of Texas has been more careless in regard to waste than have other sections of the country. The competitive system seems to have run a somewhat similar course in all oil and gas-producing regions wherever they have been found. Pennsylvania, the oldest producing State in the Union, offers as good an example of what has been accomplished under a free and unrestricted system of competition as may be found. There the matter has been left to private initiative, the State having offered little legislative interference.[1] The results are very well illustrated by the discovery and exploitation of the McKeesport gas pool, located in Allegheny County, near McKeesport, fifteen miles southeast of Pittsburgh.

This was a gas pool, oil never having been discovered. It should be recalled that porous rocks offer far less resistance to the migration of gas than to oil. Accordingly, one gas well will drain a far greater area than will one oil well. It is, therefore, possible to recover all the gas in a given pool with wide-spaced wells, whereas the greater portion of oil remains underground under any system of well spacing after the gas associated with it has become exhausted. Mr. Ashley, State Geologist for Pennsylvania, expresses the idea as follows:[2]

on the same or adjoining tract or farm, and that no well shall be drilled nearer than 150 feet to any property line save upon the approval of the Commission. The District Court of Travis County, Texas, has held the rule invalid on the ground that the statute is not specific enough to authorize the making of the rule. The Railroad Commission has appealed the case to the State Court of Civil Appeals, but no decision has yet been rendered (May 22, 1925) by this higher court. According to a communication from H. E. Bell, Chief Supervisor of the Oil and Gas Division of the Commission, 2250 applications have been made for exception to the ruling, roughly nine tenths of which have been approved.

[1] Pennsylvania long ago passed a few laws regulating the production of oil and gas, but according to information from the office of the Secretary of Internal Affairs these laws are not enforced.

[2] Ashley, George H., State Geologist, Pennsylvania, 'The McKees-

To put four holes down on a ten-acre lot is like boring four holes in a barrel of cider; the cider may come out more quickly, but no more comes out in the end, and when holes cost $15,000 or $25,000 apiece, a difference between one hole or 16 holes on an eighty-acre lease may make some difference in the financial returns. Gas companies in the business of drilling for and supplying gas allow from 80 to 5500 acres for each well.

McKeesport was a townsite, however, and offered opportunities for the small man similar to those which Burkburnett afforded. The first well drilled yielded initially about 30,000,000 cubic feet of gas and later increased to about 55,000,000 cubic feet. It was located conveniently to gas-distributing lines, several of which passed through or near by McKeesport. Accordingly, little time was lost in making connections and practically no gas was wasted. The gas was contracted for at 17 cents per 1000 cubic feet, the well thereby yielding at one time about $9350 per day. The initial investment is said to have been only $7000, so that the well paid its owners enormous dividends. An investment of $150 is reported to have yielded over $3000 the first month.[1]

An excited drilling campaign ensued and continued despite warning reports of prospective financial loss from the Pennsylvania Survey. Intensive drilling spread over about 500 acres. The initial well, on September 6, was making 30,000,000 cubic feet of gas.[2] On October 4, the flow had increased to 55,000,000 cubic feet. By October 11, the production had dropped to about 52,000,000 cubic feet. With the completion of three more wells during October the daily average production per well dropped to approximately 13,000,000 cubic feet, or the flow from four wells

port Gas Pool,' *Preliminary Report to the Pennsylvania Bureau of Topographic and Geological Survey*, January 12, 1920, p. 24.

[1] *Ibid.*, p. 1.

[2] For a graphic presentation of producing wells and average daily production per well in the McKeesport pool, see report by Samuel Wyer, *Gas Situation of the Philadelphia Company's Natural Gas Properties in West Virginia and Pennsylvania*, Plate 7.

was about the same as had been from one well. With increased completions during succeeding months the average production per well continued to decline in about the same ratio, and on May 1, 1920, 89 wells were making an average of 250,000 cubic feet per day. By June 10, the number of producing wells had increased to 145, the average daily production per well falling to 125,000 cubic feet. By December 31, 1920, 441 wells had been plugged and abandoned either as dry holes or exhausted producers, and the average daily production for 180 others was 9,460,000 cubic feet during December, a daily average each of 52,500 cubic feet. A total of 621 wells had been completed by that date, a number were still drilling, and a great many locations had been abandoned.[1]

The first well is said to have cost only $7000, but during the drilling campaign contracting prices rose very greatly, and by January 1, 1920, contracts for wells were reported at $25,000.[2] So great was the demand for drillers that operations in other portions of Pennsylvania were temporarily impeded due to their exodus to the McKeesport field. It is impossible to compute an accurate average for the cost of the 621 or more holes that have been drilled in this field, but in view of the exceedingly high contract prices that prevailed in January, 1920, when activities had reached their peak, $12,000 per well would seem to be a conservative figure. On this basis 621 wells cost in the neighborhood of $7,452,000. Two wells drilled at a total cost of $15,000 would probably have secured the same amount of gas. The waste by duplication in this field as represented by this rough calculation would therefore approximate $7,437,000. The total yield of the field up to January 1, 1921, was 16,737,650,000 cubic feet, which at 17 cents per thousand had a commercial value of $2,845,411.[3]

[1] Robinson, J. French, 'Production of the McKeesport Gas Pool,' *Report to Pennsylvania Bureau of Topographic and Geological Survey*, January 24, 1921, *passim*.

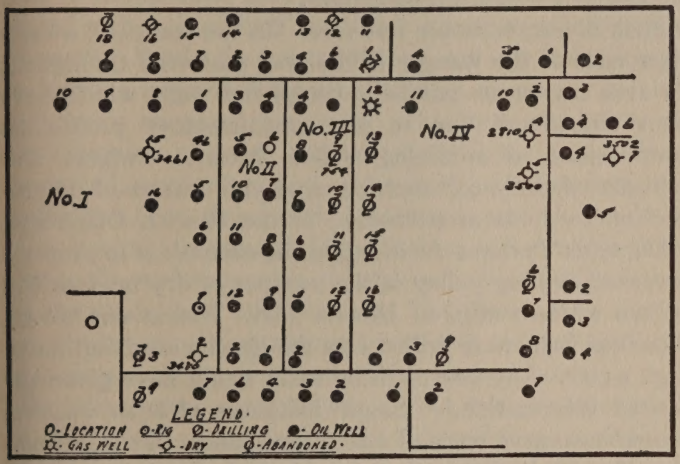
[2] Ashley, *op. cit.*, p. 3.

[3] Robinson, *op. cit.*, p. 6.

As evidenced by the foregoing illustrations, a competitive race for oil or gas may result in a tremendous increase in production costs. A larger number of oil wells may lead to an increase in the total volume of oil recovered; frequently they do so at a cost scarcely justified by the value of the additional recovery. Intensive drilling, however, results in an increased rate of recovery. Under competitive practices speed of operation is the all-important factor. The result from a social and individual viewpoint has frequently been an enormous increase in the cost of production through unnecessary and wasteful duplication. Not only has the competitive factor, speed, resulted in loss from drilling more wells than are necessary to adequately drain the underground sands, but it has also led to an increased number of unproductive wells and to the frequent abandonment of partially completed wells which represent a total loss. The migratory nature of oil makes it highly desirable for an operator to complete a drilling programme before the competitor on an adjoining lease does so. A large volume of petroleum may thereby be quietly sucked from under the neighbor's tract. Accordingly, an operator is under a strong urge to begin his drilling programme on a large scale. All line wells are frequently begun simultaneously, or nearly so. Such a defensive offense necessitates a counter-attack by the competitor. Should the wells prove productive advantage accrues to the concern first to complete its programme. But oil production is an uncertain and hazardous enterprise, and the exact limits of a discovered pool can be determined only by experimentation. Should new wells prove dry, as is ofttimes the case, the loss is enormously increased by competitive methods. Properties III and IV on the accompanying map (see Figure XV), showing a portion of the Ranger, Texas field, illustrate the point in question. There may be noted four pairs of abandoned derricks adjoining the boundary line separating these properties. These locations had been made simultaneously or nearly simultaneously with the other locations on Property

III. Derricks were constructed preparatory to a race in oil extraction. The contestants were on their marks but the starter's pistol contained a blank cartridge. Wells on Property III were completed with a much smaller production than had been anticipated. The last completion showed only ten barrels and was almost a total failure.

FIGURE XV. MAP OF A PORTION OF THE RANGER, TEXAS, OIL FIELD



Note the large number of abandoned wells, the result of low yield from earlier completions. Had the pool been operated on a basis of geologic structure rather than on a basis of property lines, most of these abandoned wells would probably never have been started.

Accordingly it was not deemed desirable to continue with wells 9, 10, 11, and 12 on this tract, and the offset locations were also abandoned, but not until derricks had been completed and a considerable expenditure had been made. Each derrick represented an approximate expenditure of $5000. On Property IV a total of 16 locations were made. Seven wells were completed as producers, but production reports covering the property indicate that only one of these completions, with an initial production of 1300 barrels, was a commercial success. The other six as indicated by their initial production could scarcely have paid

for the cost of drilling. Two other wells, No. 4 and No. 5, were completed but both proved to be dry and were immediately abandoned. One well, No. 12, encountered a gas stratum and was closed in as a gas well. Six locations were never drilled, but derricks were constructed on each at a per-well cost of about $5000. The loss from incompleted and abandoned wells on this tract alone ran well into the hundreds of thousands of dollars.

Such illustrations are not rare. On the contrary, a complete map of the Ranger field shows scattered throughout its area numerous partially completed wells which have been abandoned due to the unsatisfactory production performance of adjoining wells. Messrs. Swigert and Schwarzenbek, in commenting upon this feature of oil production methods as evidenced in the Hewitt, Oklahoma, fields, said: 'Perhaps the most glaring example of improperly governed drilling policy is the number of dry holes drilled on the western edge of Hewitt field. Within one week's time four wells were drilled into the Hewitt sand and found edge water. Any one of these wells would have given the desired information.' [1] Single instances of such wasteful expenditure may seem of little importance, but were complete figures available they would no doubt command the attention of the most improvident. And whether or not, they represent a charge which is borne by the industry at large and which is represented in the long run by higher prices or decreased profits. The point to be emphasized is that whether large or small, such waste from the broader industrial point of view, is frequently unnecessary and might largely be eliminated.

[1] Swigert and Schwarzenbek, *op. cit.*, p. 29.

CHAPTER IX

WASTE OF GAS

Waste of Gas Pressure

The argument, thus far, has dwelt chiefly upon the waste due to an increased cost per quantity unit of oil or gas produced rather than upon the waste due to an incomplete oil recovery. While the former matter has not seemed inconsequential, in view of the rapidity with which our domestic petroleum resources are being exhausted, the latter is a consideration of much greater importance. As previously explained much of the oil is retained in the ground after wells have been abandoned. Under any method of exploitation, it would be impossible to obtain a complete extraction due to the surface tension of petroleum, frictional resistance of the sands, and other factors. Yet there seems to be a unanimity of opinion among petroleum technologists that a greater volume of oil might be secured under a more scientific manner of exploitation. The two principal causes of incomplete oil extraction are the ineffectual and partial utilization of gas pressure and the flooding of oil sands [1] by underground waters.

When the volume of gas associated with the oil in the underground stratum is greater than the amount which the oil can absorb, it is found in a free state, located in the upper portions of the underground folds, the oil and gas having arranged themselves on a basis of specific gravity. If the pressure is not too great, a portion of the more volatile fractions of the petroleum may be held in suspension in the free gas as vapor, very much as water is held in the atmosphere.[2] As previously explained, when the drill punctures the restraining stratum and exploitation begins, gas

[1] The term 'sand' is a field term to denote any producing stratum. Oil and gas may be found in other than true sand formations.

[2] Lewis, J. O., *op. cit.*, pp. 11–13.

under pressure migrates toward the opening and carries the oil with it, but the gas which is more mobile than the oil slips through the pores of the sand more readily and escapes at a more rapid rate. The pressure becomes exhausted long before all the oil has been recovered. The amount of oil recovered depends in large part, therefore, upon the extent to which the escaping gas is utilized as a motive force to bring it to the surface. In the words of Mr. Lewis, 'The proportion of oil recovered from an oil sand may be said to represent a balance of the energy originally stored in the oil sand with the waste of energy and the opposition to the expulsion of the oil.' [1] If the release of the gas pressure were so controlled that the amount of oil recovered per unit volume of gas released were increased, the ultimate oil recovery would be proportionally increased, even though the daily rate of production were diminished. Without competition, with the oil fields operated as a geological unit, with a carefully planned spacing of wells, with due regard to underground conditions, and with experimentation upon the rate of flow per well (a matter subject to control by mechanical appliances) the rate of production could be so regulated as to ensure a maximum recovery for each field. With the location of wells determined by property lines and their rate of flow unregulated under the stress of a competitive race in oil extraction, much of the gas may escape without having performed its quota of work.

If the release of gas pressure were so controlled that the amount of oil recovered per volume of gas released were increased, the ultimate oil recovery would likewise be increased, although the daily rate of production might be perceptibly decreased. If, for example, a change in method of operation reduced the volume of gas produced from 2000 cubic feet to 1000 cubic feet with each barrel of oil recovered, the life of the field would be prolonged and the ultimate production would be increased, but the actual daily pro-

[1] Lewis, J. O., *op. cit.*, p. 21.

duction would probably be materially reduced. It should be noted that the rate of gas flow from a well is subject to mechanical regulation. Under customary methods of oil exploitation the pipe through which the oil is recovered has a diameter of about six inches.[1] The gas escapes through the conduit readily, the open-flow volume of gas for many oil wells frequently running into the millions of cubic feet a day. By the introduction of a 'bean' or flow nipple the size of the opening through which the gas escapes, and hence the rate at which it escapes, may be reduced. The rate at which the oil escapes will also be reduced, but it has been found by experimentation that in many instances the rate at which the oil escapes is not reduced to a like extent. Where there is little opposition to the escape of gas from an underground sand it very readily leaves the oil behind. Where its progress is impeded it will bring with it by percentage a greater volume of oil. By experimentation it can therefore be determined what rate of production is most efficient. In the California fields natural conditions in many instances have made it imperative to restrict the flow of gas from the wells in this artificial manner. When production is from loose and unconsolidated sands the gas under pressure frequently carries the sand into the hole and thereby impedes the recovery process. When the abrasive force is great it may interfere materially with the mechanics of the operation, and cause the well to get beyond control. In some regions it has been found necessary to restrict the flow of the well.

In some of the California fields wells capable of producing as much as 10,000 to 15,000 barrels of oil a day, and making in addition several million feet of gas, are restricted to a flow of 1000 barrels a day or less, with a comparatively small flow of gas, by closing the well to a ½-inch or a 1-inch opening. It has been found that the ultimate flush production from such restricted wells has almost invariably been more than the unrestricted flow from neighboring wells.[2]

[1] This may vary with local conditions.

[2] McMurray, W. F., and Lewis, J. O., *Underground Wastes in Oil*

The mechanical appliances are at hand, therefore, by means of which the efficiency of the recovery process might be increased, but under the urge of competitive endeavor, they are rarely used.[1] The division of a geological unit into dozens or perhaps hundreds of operating units on an ownership basis is conducive neither to efficiency nor economy. But the production of oil is conducted as a business enterprise, rather than an industrial process. Since oil is of a roving nature, speed becomes the sole protection of the small holding, and all else must be sacrificed to it. Try to persuade the owner of a five-acre plot, which is surrounded on every side by producing wells, that it is to his advantage to reduce his daily output from five thousand barrels to perhaps one thousand barrels in order that the entire pool may ultimately yield a greater recovery! Hardly. When a new pool is opened an excessive quantity of gas is generally produced with the oil. The custom is to permit wells to flow at full capacity. No effort is made to control the excessive flow of gas, for to hold it back will temporarily retard the productive process. The provident producer is at the mercy of the improvident; and improvidence is nurtured by the competitive system.

The effective utilization of gas as a motive power in oil production, however, is not entirely a matter of regulating its rate of flow. The route which it follows in its escape to the surface is of fundamental importance. A study of Figure XVI may make this more evident. Free gas, unabsorbed by the oil but in intimate contact with it, is frequently found in the higher portions of the underground folds. The sketch is a hypothetical illustration of such a condition.[2] The underground geological unit is arbitrarily

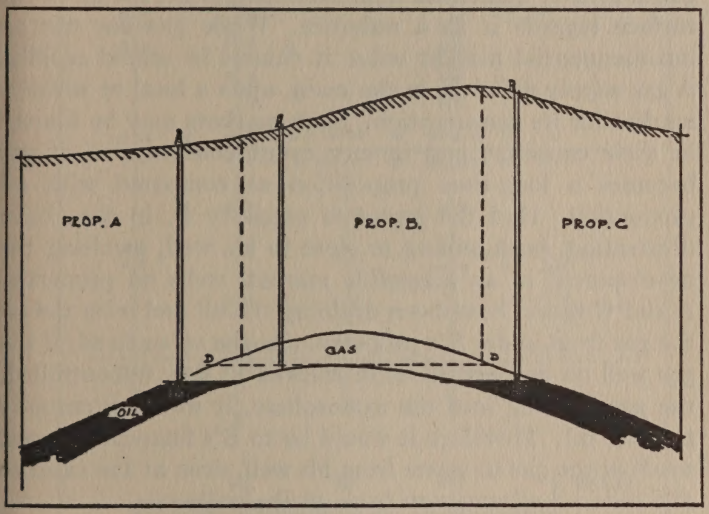
and Gas Fields and Methods of Prevention (Bureau of Mines, Technical Paper 130, 1916), p. 17.

[1] Except, of course, where natural conditions necessitate, as in certain areas in California. They have been used so little outside of the California fields that it is not known definitely what results might be secured.

[2] The sketch is somewhat exaggerated, but it illustrates the principles involved.

divided for exploitation by property lines. A well drilled on property B would obviously produce gas at first. With each day of gas production there would be a reduction in the volume and pressure of the gas, and the oil would gradually migrate upward until eventually it would occupy the

FIGURE XVI. SKETCH SHOWING THE TYPICAL UNDERGROUND OCCURRENCE AND DISTRIBUTION OF OIL AND GAS IN THE SAME STRATUM



This sketch illustrates how a well may at first produce only gas, but may later begin producing oil if the gas is allowed to escape. As the volume of gas is decreased the oil migrates up the slope until it occupies the position shown by the dotted line, *D-D*, at which time the well will begin producing oil with the gas. The division of such a geological unit by property lines for purposes of exploitation places a premium upon the waste of gas, for should the well on property *B* have been closed in until the gas had been utilized, wells on properties *A* and *C* would have been draining out the oil, and with the oil, the gas from under property *B*.

position shown by the dotted line D–D, at which time the well would begin to produce both oil and gas. The volume of oil would increase to a certain point when with further decline in gas pressure it would decrease, the well ceasing to flow when the pressure was entirely exhausted. Under such a hypothetical case, the gas which would have escaped before oil production had begun would represent un-

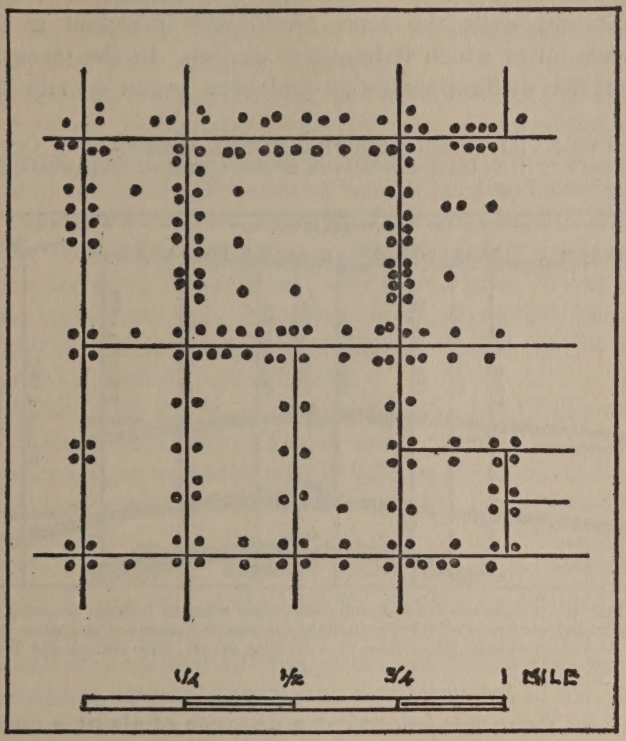
utilized energy and would mean a lessened ultimate oil recovery. Had the well been drilled on either property A or C it would have produced oil from the beginning and all the escaping gas could have been utilized for oil expulsion.

Such a natural geological arrangement as set forth above puts a premium upon the waste of gas valuable both as a fuel and as an energy resource. The operator who strikes gas in greater quantities than necessary to lift the oil to the surface regards it as a nuisance. While gas has not an inconsequential market value it cannot be stored readily. A gas supply depends, in the main, upon a local or near-by market for its consumption. Such markets may be limited in their capacity, and in any event consumption of gas becomes a long-time proposition as compared with oil production. Had the owner of property B, in the above illustration, been willing to close in his well, awaiting the development of an accessible market, wells on properties A and C would have been draining the oil and with the oil the gas from under B's property. On the other hand, if the gas well on property B were allowed to flow uncontrolled, the gas blowing into the atmosphere, it would eventually produce oil. Therefore it would be to B's financial interest to allow the gas to waste from his well, even at the expense of a reduced oil recovery from all the wells.

The above illustration has been hypothetical. Figures XVII and XVIII portray the actual surface well locations and the underground disposal of oil, gas, and water in a section of the Cushing, Oklahoma, oil pool, and illustrate, similarly, a geological unit divided arbitrarily by property lines as a basis of exploitation. To calculate the volume of oil wasted through incomplete recovery resulting from such methods of extraction is obviously impossible, for it would mean a determination of the differences between the amount of oil recovered and the amount which might have been recovered under unified, scientific operation. But in the words of Mr. Lewis:[1] 'Every foot of gas produced waste-

[1] Lewis, *op. cit.*, p. 118.

FIGURE XVII. MAP SHOWING RELATION OF OIL WELLS TO PROPERTY LINES IN THE CUSHING, OKLAHOMA, OIL FIELD



Note the small holdings, the great number of wells and the tendency for wells to occur in pairs on opposite sides of property lines. This plot illustrates the manner in which the underground geological unit, the oil and gas pool pictured below, was exploited. (Data from map by C. W. Beal, *Geological Structure in the Cushing Field, Oklahoma.* Bulletin 658, United States Geological Survey, 1917. After Gilbert and Pogue, *op. cit.*, p. 86.)

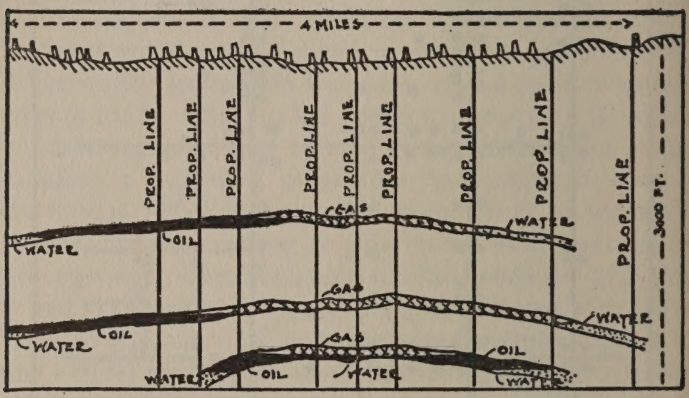
fully may be considered to represent a quantity of oil that should have been brought to the surface by using the gas effectively.' With this in mind let us examine a few typical cases that may indicate the significance of actual field losses.

In March, 1920, the discovery well was completed in the Stephens County, Oklahoma, oil field.[1] This well was lo-

[1] The following illustration did not come under the writer's personal

cated on a 160-acre farm. The initial production was approximately 750 barrels. With the completion of seven additional wells the lease production increased to 6000 barrels, after which it began to decline. In the meantime an active drilling campaign had been begun on adjoining

FIGURE XVIII. SKETCH SHOWING ACTUAL UNDERGROUND OCCURRENCE OF OIL, GAS, AND WATER IN THE CUSHING, OKLAHOMA, GAS AND OIL FIELD



This sketch illustrates the customary discordant relations between property lines and geologic occurrence. It epitomizes the fundamental causes of petroleum waste in the United States. (Data from Carl H. Beal, *op. cit.*, after Gilbert and Pogue, *op. cit.*, p. 87.)

tracts. Two wells located at a distance of about a quarter of a mile 'came in' unexpectedly about June 1 as gas wells. The total production on the above tract at this time was approximately 4700 barrels. With the completion of the gas wells, which 'ran wild' for several weeks, the oil production on the 160-acre tract dropped 500 barrels over night, and rapidly declined thereafter. Despite the completion of four additional wells the production on July 1, four weeks later, was down to 2300 barrels. Meanwhile several other gas wells were completed, one of these being an offset to a 300-barrel oil producer on the 160-acre farm. This well

observation. The figures are estimates secured, however, from the man who gauged the oil on the property in question.

dropped to 200 barrels with the completion of the gasser. Before the latter well had been shut in, all the oil wells on adjoining property had ceased to flow naturally and it was necessary to place them on the pump.

On April 30, 1919, a gas well was completed on the Tobe Morton farm in Eastland County, Texas. The well had an estimated open-flow volume of 25,000,000 cubic feet per day, and the total daily volume was allowed to waste into the atmosphere in the hope that the well would begin making oil. With reduction in the gas volume the well began producing oil, and on October 17, 1919, it was reported a 50-barrel well. No offsets had been drilled, but all the gas which escaped before the production of oil represented a potential oil recovery.

Well No. 2 on the H. H. Vaught farm in the Desdemona field of Eastland County, Texas, was completed on August 9, 1919, as a gas well with a daily volume of 6,000,000 cubic feet. After 'running wild' a week it was reported as a 250-barrel oil well.

Well No. 1 on a Walker-Caldwell tract in Stephens County, Texas, was completed on or about February 28, 1920, with an estimated open flow of 7,500,000 cubic feet. The well was allowed to 'run wild' and within two weeks was making, approximately, the same amount of gas and 200 barrels of oil. By April 1, the oil production had increased to 275 barrels per day.

Swigert and Schwarzenbek, in commenting upon the practice of 'blowing in' gas wells in the Hewitt, Oklahoma, field have the following to say:[1]

> Many operators fail to realize the extreme value of gas in a well. Besides the fuel value of gas it is known that gas is the medium which expels oil from the sand and flows it to the surface and it is common knowledge that as the rock pressure of a field declines the new oil wells come in with smaller productions. This is in perfect accord with known physical laws. Blowing gas wells open is a practice that should be discontinued. By blowing gas wells open the short-

[1] Swigert and Schwarzenbek, *op. cit.*, p. 74.

sighted operator sometimes accomplishes one purpose, namely, his well blows into an oil well, but in blowing his well, a loss of a valuable natural fuel occurs, as well as a loss in future production. Once gas is blown off, the relative 'dead' oil will not enter the hole. The ultimate recovery is in this way reduced. The fact that this does the industry real damage should be considered by owners of gas wells.

It seems hardly necessary to remark that this criticism of the 'short-sighted' operator is perhaps unkind, and certainly beside the point. The 'short-sighted' operator may be a 'far-sighted' business man, interested in securing a profit from the particular tract which he controls. Under the competitive system he can scarcely be expected to forego the possibility of securing some oil on his property in order to increase the ultimate production from the field at large.

In each of the cases enumerated above, the gas that escaped prior to oil production represented a waste of oil that might have been recovered from an adjoining property. Other illustrations might be given, but at best they are only indicative since the extent of wastage is largely a matter for conjecture and does not admit of accurate measurement.

Waste of Gas as a Fuel

Thus far the consideration in regard to waste through dissipation of gas has been centered upon the loss of available pressure. In the illustrations given above the gas needlessly expended represented a waste not only of energy but of a valuable fuel.[1] The more important consideration would seem to be the waste due to incomplete oil recovery, but the waste as a fuel is capable of more accurate meas-

[1] It should be observed, however, that in some cases it may not be economical to save such gas for fuel purposes. Its utilization depends upon the development of local or near-by markets, and to retard the rate of oil production to the gas-consuming capacity of small local markets might result in a less effective recovery of oil. It should be remembered, on the other hand, that a retarded gas flow might mean a greater ultimate recovery.

urement. This latter appears in two typical forms, waste of gas from a stratum also containing oil, as in the illustrations given above, and waste from gas sands as distinct from oil sands. Very often in drilling for oil, stray sands may be encountered containing only gas. In such instances the gas is regarded by operators in the main as a distinct nuisance, calculated only to delay the drilling process, thereby handicapping the operator in a competitive race for oil. It is interesting to note that a method has been devised for preventing the waste of gas from these stray sands, namely, drilling with a mud-laden fluid in the hole. Under this method small particles of clay suspended in the fluid and under pressure from the column of water enter the sand pores and seal off the gas stratum, preserving the conduit intact down to the production horizon, and thereby preserving the gas in its underground reservoir for future exploitation.[1]

So, although the means have been available for elimination of gas waste, by and large, they have not been applied. Reasons for this are not entirely lacking. The amount of gas may be insufficient, from the operator's point of view, to justify its being saved. More particularly, the use of mud-laden fluid is said to slow down drilling operations. Greater care must be exercised. The tools must be run in and extracted at slower speed. There is also a greater tendency for them to stick. It may often be necessary to circulate fresh fluid in the hole. When the gas pressure is strong, it may be necessary to put extra pressure on the fluid with a pump. All this means greater care, slower and more painstaking drilling, factors that hardly fit into the scheme of things under the competitive system. Any slowing down of operations gives the competitor on an adjoining tract an increased advantage. The wells are generally drilled by contract at a stated price per foot. Speed, therefore, becomes a prime consideration both to the

[1] Lewis and McMurray, *The Use of Mud-Laden Fluid in Oil and Gas Wells.* Bulletin 134 (U.S. Bureau of Mines, 1916).

drilling contractor and to the oil operator. Despite the seeming or real disadvantages of the use of mud-laden fluid, to the technologist it seems a desirable practice, and we are told that apparent disadvantages connected with its use are far outweighed by the saving effected.[1] Yet the operator seems unconvinced. In actual practice instead of using the mud-laden fluid method, one of the following means of handling the gas problem is generally utilized.[2] If the gas is not of sufficient volume and pressure to make operations impossible, drilling is continued and the gas is allowed to blow into the atmosphere. In the course of a few weeks the gas may escape, or water may later be encountered, which would fill the hole and by its weight drown out the gas sand — the gas migrating under pressure of the encroaching water. If the volume of the gas is so great as to render drilling impossible, the well may be allowed to 'blow wild' until the pressure subsides, whereupon drilling may be resumed. Or, finally, should the gas be from an oil stratum the well may 'blow itself in' as an oil well.[3]

Obviously, a proper appreciation of the extent of the waste which the above destructive practice has occasioned involves a consideration of the volume and value of the substances wasted. An analysis of the gas produced from a number of wells in the general region of the Stephens County and Ranger fields showed that one cubic foot of gas had a heating value of 1127 B.T.U.[4] According to the United States Bureau of Mines a good steaming coal develops 13,500 B.T.U. per pound.[5] Applying these figures, we find that 1,000,000 cubic feet of gas in the field under consideration has a heating value of 41.7 tons of coal.

[1] Lewis and McMurray, *op. cit.*, pp. 24 *et seq.*

[2] That is, in the absence of legal restraint and interference.

[3] These are generalizations to which there are exceptions. Reference is here made to gas encountered in search for oil. Wells are often drilled for gas in certain localities.

[4] The test, conducted by one of the large oil and gas companies operating in this section, included an analysis of six samples which showed an average net heating value of 1127 B.T.U.

[5] Huntley and Johnson, *Principles of Oil and Gas Production*, p. 7.

Natural gas has long been regarded by the consumer as an ideal fuel because of its cleanliness, the ease with which it may be handled, its heat-producing quality, and its low price as compared with other fuels. With these facts in mind the waste of gas in oil production becomes more significant.

Beginning in June, 1919, and extending throughout that year, a number of tests were made at successive intervals in the Eastland County, Texas, fields under the supervision of the Oil and Gas Division of the Railroad Commission of Texas, assisted by a representative of the Lone Star Gas Company. The purpose of these tests was to ascertain, on the one hand, the amount of gas then wasting, with an idea of determining the practicability of initiating a conservation campaign under the authority vested in the Railroad Commission through legislative enactment. On the other hand, it was hoped to locate a source of gas supply for domestic consumption to relieve the acute shortage then existing in certain Texas cities.[1]

The investigation covered more than 67 wells, with a combined daily production of nearly 1,000,000,000 cubic feet, all of which had at one time 'run wild.' The daily waste per well ranged from about 1,000,000 to 100,000,000 cubic feet, and the time that the wells were uncontrolled varied from a few weeks to over six months. On 20 leases there was, at one time, a daily waste of 238,000,000 cubic feet of gas, the equivalent of over 9934 tons of coal, and having at the prevailing consumer's price a commercial value of $107,100 daily and at field prices a value of nearly $12,000 daily.[2]

One well tested in June showed a daily waste of 70,000,000 cubic feet and the same well in November tested 100,000,000 cubic feet. This well 'ran wild' for approx-

[1] The following data were secured from the office of the Oil and Gas Department of the Texas Railroad Commission, Austin, Texas.

[2] Considering price for domestic consumption, 45 cents per 1000 cubic feet, and price for field use, 5 cents per 1000 cubic feet.

imately six months and was one of the biggest gas wells ever discovered in the United States. During this period the gas escaped from the well with such great velocity that the roar could be heard for miles. The well was later connected with the pipe line of a distributing company and marketed in the field for drilling purposes. But during the time it was uncontrolled it wasted daily the fuel equivalent of over 3300 tons of coal, the daily waste of gas having a value of over $36,000 at consumers' prices and over $4000 at field prices. During five and one half months it wasted approximately 13,200,000,000 cubic feet of gas,[1] the fuel equivalent of approximately 550,000 tons of coal. It would have supplied over 132,000 families[2] with fuel for a year at a cost of over $5,940,000, and at field prices the gas would have brought over $660,000.

Tremendous as these wastes may seem they have not been unusual, nor are they peculiar to any one locality. Rather, they have been ubiquitous and persistent characteristics of oil field practices. In the absence of governmental restriction they are customarily regarded as necessary and unavoidable, a part of the system under which they manifest themselves. Van H. Manning, until recently director of the Bureau of Mines, sums up the subject in the year book of that institution for 1916.[3] He points out that in the Cushing, Oklahoma, field (see Figures XVII and XVIII, pp. 171, 172) during the year 1913 there was an average daily waste of not less than 300,000,000 cubic feet, or more than 100,000,000,000 cubic feet in the course of a year, the equivalent of about 5,500,000 tons of coal. This amount of gas would have been about sufficient to have supplied the entire city of New York with fuel for domestic purposes during the period it was wasting, had it been available in this locality. Mr. Manning says:[4]

[1] Assuming the average daily waste for the five and one half months to have been 80,000,000 cubic feet.

[2] Allowing 100,000 cubic feet per family per year.

[3] Manning, Van H., *Yearbook of the Bureau of Mines*, Bulletin 141, 1916, pp. 122–124.

[4] *Ibid.*, p. 123.

Not only was the gas allowed to waste, but such tremendous volumes of this inflammable material hung over the oil fields that automobiles were not allowed to enter, and in many cases disastrous fires were started, resulting in the loss of life and property.

All this gas was wasted in order to produce about 30,000 barrels of oil daily; in other words, at the prevailing price paid by domestic consumers for such fuel, gas worth about $75,000 a day was needlessly wasted to obtain a daily oil production valued at less than $25,000.

Mr. R. S. Blatchley, summing up the waste in the Mid-Continent field estimated that the waste of gas prior to 1913 was 425,000,000,000 cubic feet. This wasted gas at the rate the product was then consumed in Oklahoma would have been sufficient, if wisely exploited, to have served the State for over sixty years. 'The intrinsic value of this lost gas, if it had been saved, would doubtless exceed the value of the oil that has been produced from these fields.' [1]

Waste of Natural-Gas Gasoline

As previously explained, natural gas when associated with oil contains a portion of the more volatile petroleum components suspended in the gas as a vapor. On the basis of gasoline content, natural gas may be divided broadly into two types, dry gas and wet, or casing-head, gas. The former ordinarily comes from what has usually been termed a true gas sand as distinguished from an oil sand and in general carries with it very little gasoline vapor. Wet gas, on the other hand, as the name suggests, is produced in connection with oil coming from the same stratum with it or prior to its production, and often is rich in the more volatile components. In the discussion thus far, gas has been regarded only from the standpoint of its fuel value and its energy value as a motive force for oil extraction. The waste in this regard has not been inconspicuous, and yet to leave the matter at this point would be to do the subject scant justice. During the natural flow of a well the oil is accom-

[1] Blatchley, *Waste of Oil and Gas in the Mid-Continent Fields*, Technical Paper 45 (U.S. Bureau of Mines, 1913), p. 47.

panied by a greater or less amount of wet gas, the gasoline content varying with the volume of the gas, the character of the oil, and the pressure. When an oil well first begins to flow the gasoline content may be quite small, but as pressure is reduced absorbed gas is released from the oil, carrying with it quantities of gasoline vapor. 'At every reduction of pressure there is a corresponding liberation of gas and an increase in the quantity of gasoline vapors, so that the gas becomes richer and richer as the pressure is reduced, and is more desirable for the making of gasoline.'[1]

In the field, the common practice in handling the gas in connection with oil production has been to connect the well with a flow tank which is provided with an open flue at the top. Here the oil and gas separate on a basis of specific gravity. The oil is led into a stock or lease tank, and the gas, carrying with it the more volatile petroleum constituents, is allowed to dissipate into the atmosphere. Within the last decade there have come into more general use mechanical devices known as gas traps, by means of which the oil and gas are separated and the latter, after treatment in a natural-gas gasoline plant, is utilized on the market for fuel purposes. After separation, the gas may be treated by either of two methods: the absorption process[2] or the compression and refrigeration process.[3] As the name suggests, the absorption process consists in conveying the gas into intimate contact with a heavy oil, which under pressure absorbs the gasoline vapor, and later upon distillation is made to give it up as gasoline. In the compression process the gas is compressed and chilled, the oil vapor squeezed out, and later condensed as gasoline. In either method the gasoline produced is highly volatile, and is blended with the lower grade naphthas to form commercial

[1] Lewis, J. O., *op. cit.*, p. 13.

[2] Dykema, W. P., *Recent Developments in the Absorption Process for Recovering Gasoline from Natural Gas*, Bulletin 176 (U.S. Bureau of Mines, 1919).

[3] Dykema, W. P., *Recovery of Gasoline from Natural Gas by Compression and Refrigeration*, Bulletin 151 (U.S. Bureau of Mines, 1918).

gasoline. These processes have long since passed out of the experimental stage, having been employed for over a decade on a commercial basis. Progress in this regard is indicated by concrete figures showing the increase in production of natural-gas gasoline during the past ten years. In 1913, 24,061,000 gallons of natural-gas gasoline were produced in the United States while in 1923 the domestic production of natural-gas gasoline had mounted to 816,226,000 gallons.

While the practice of utilizing natural-gas gasoline had apparently gained considerable vogue, the fact remains that in general a large proportion of the gas and gasoline vapor accompanying petroleum production has been allowed to waste into the atmosphere.[1] Why, it may be asked, if the manufacture of natural-gas gasoline has proven a profitable undertaking, has it not been more generally practiced? The answer to this question involves again a consideration of the competitive system. To install a compression plant capable of handling 1,000,000 cubic feet of gas daily, involves an investment of approximately $36,000.[2] To install an absorption plant capable of handling 10,000,000 cubic feet of gas will cost from $15,000 to $20,000.[3] Under the hurried methods of competition, when oil is discovered in a new pool speed becomes of first importance, every other factor being sacrificed to it. Accordingly, the greatest waste occurs during the early life of a field. Little attention is given to the utilization of by-products. This must come later if at all. The choice of a location of a gasoline plant depends upon the character of the gas, the quantity that may be available, the probable life of a well, and the possibility of connecting with other properties in the district after abandonment of the original wells. These are matters

[1] Reference is here made particularly to gas accompanying oil production. Several States have laws forbidding gas wells 'running wild,' a distinction being made between oil and gas wells.

[2] Dykema, W. P., Bulletin 151, *op. cit.*, p. 96.

[3] Burrell, Biddeson, and Oberfeld, *Extraction of Gasoline from Natural Gas by Absorption Methods* (U. S. Bureau of Mines, 1917), Bulletin 120, p. 44.

that cannot be determined in the early history of the field. Where the properties are small and many wells are completed at the same time, the gas is dissipated as rapidly as can be. There is little inducement for a fixed investment, since such an investment would depend upon the life of the wells for the source of its raw material. That natural-gas gasoline plants are not more frequently installed may be a matter of ignorance, carelessness, and indifference, characteristics of the hasty, haphazard methods of the competitive system. As it has worked out in practice, in the main, in the early life of a field, the gas has been allowed to dissipate into the atmosphere without ever having been tested for volume or gasoline content.

The result is that millions of cubic feet carrying thousands of gallons of gasoline have been wasted, the extent of the loss being a matter of conjecture rather than of accurate measurement. That some proper idea may be gained of its possible magnitude, a few specific and general production data may not be amiss. The commercially valuable wells in the Ranger field came in with an initial production varying from a few hundred barrels of oil to several thousand. It required considerable gas pressure to lift this body of oil to the surface; the estimated volume of gas accompanying the oil flow varied from thousands to millions of cubic feet. The gasoline content differed, of course, both with the various wells and in the life history of single wells. Fifty-eight wells, later connected with Chestnut and Smith Gasoline Company's plants, yielded from ½ to 1½ gallons of gasoline to 1000 cubic feet of gas.[1] As little 'as one quart per 1000 cubic feet or even less can be treated to advantage by this [the absorption] process, when the quantity of gas is large enough to pay the cost of its maintenance.'[2] Several examples have already been given of oil wells accompanied by millions of cubic feet of gas which was blown into the

[1] Personal interview with L. A. Vanderwoort, manager, Chestnut and Smith Casinghead Gasoline Company, Ranger, Texas.

[2] Huntley and Johnson, *op. cit.*, p. 175.

atmosphere. A few other conspicuous examples might be added. On May 18, 1919, there was completed a 5800-barrel oil well on the Swensondale farm, Stephens County, Texas. The oil was accompanied by an estimated gas flow of 10,000,000 cubic feet. This well was connected with the customary flow tank in which the gas separated from the oil and wasted into the atmosphere. At the end of one year the well was still producing over 200 barrels of oil daily, and had an estimated gas flow of 2,000,000 cubic feet. The gas had never been tested for either gasoline content, pressure, or open-flow volume.

On January 17, 1920, a 1200-barrel oil well was completed on the A. J. Erwin farm in the Desdemona, Eastland County, Texas, field. The well was accompanied by an estimated gas flow of 20,000,000 cubic feet and was connected with the customary 'gun barrel' flow tank, the gas being allowed to dissipate. After the well had flowed for about four months, a test was made on or about May 20, 1920. On a basis of this test it was stated that every 1000 cubic feet of gas was capable of yielding four gallons of high-grade gasoline.[1] At this time the well had an estimated flow of 12,000,000 cubic feet of gas. On a basis of this volume, one day's flow meant the wastage of 48,000 gallons of gasoline, which at 25 cents per gallon had a commercial value of $12,000. At this time the well was producing 550 barrels of oil per day, which at $3.50 per barrel had a commercial value of $1925. During the four months' period the well had wasted approximately 1,920,000,000 cubic feet of gas, which at the current field prices had a value of $96,000 for fuel purposes and carried in addition a gasoline content of perhaps 5,760,000 gallons.[2] The gasoline at 25 cents per gallon had a commercial value of $1,440,000. The waste

[1] This information was secured by the writer from the field office of the operating company. The writer was at the well several times in the spring of 1920.

[2] The gas tends to grow richer with decline in pressure. This calculation is made on the assumption that the average content of all the gas wasted was three gallons per thousand cubic feet.

from these two sources totaled $1,536,000 during the four months' period. During the same time the well produced approximately 64,533 barrels of oil which was saved and at $3.50 per barrel yielded $225,865. The gasoline wasted from this one well in the four months totaled an amount equal to more than two fifths of 1 per cent of all the gasoline manufactured in the United States during the same period.[1]

Prior to the completion of the above well, the same company had completed on an adjoining tract in October, 1919, a well with a reported initial production of 2700 barrels. This well was accompanied by such a large volume of gas under such tremendous pressure that it was necessary to distribute its flow into two tanks since, if only one had been used, there would have been danger of its having been blown to pieces. The gas had not been tested for either gasoline content or volume and was allowed to waste. At the time the Erwin well was tested, this well was still making about 300 barrels of oil daily and considerable gas, after having flowed for over six months. After the test was made on the Erwin well, the construction of a natural-gas gasoline plant was immediately begun to handle the gas from these two wells and any other that might be available in the neighborhood.

In February, 1920, well No. 2 was completed on the W. L. Thornton farm in the same field, with an initial production of 800 barrels, and an estimated gas flow of 8,000,000 cubic feet. A gas trap was installed and a portion of the gas was utilized for drilling operations, at one time supplying seven boilers with fuel. The excess was piped to one side and was allowed to blow into the atmosphere through a small two- or three-inch pipe, the amount of waste varying with the amount of gas needed for immediate consumption in drilling operations. In the latter part of May,

[1] Total gasoline production for the United States for February, March, April, and May, 1920, was 1,426,403,117 gallons. Data from U.S. Bureau of Mines.

1920, the well was making approximately 750,000 cubic feet of gas, all of which was wasting, since drilling operations had been completed in this locality. A test made on or about May 15 by the company in charge of operations showed the gas to have a gasoline content of a little over five gallons per 1000 cubic feet. The daily waste, therefore, was capable of yielding approximately 4000 gallons with a commercial value of $1000. After the test, plans were made for the immediate construction of a natural-gas gasoline plant.[1]

The discovery well of the Desdemona field was completed in September, 1918. The pool was located on and adjoining the townsite, and accordingly offered excellent opportunities to the small investor, the promoter, and the lease salesman, each town lot affording a potential drilling site. Wells, accordingly, were spaced very closely; a rapid drilling campaign was instituted; and by May, 1920, seven hundred and ten wells had been completed. One hundred and fifty of these were dry holes and thirty-two were gas wells. Many came in for large initial daily productions, some going into the thousands of barrels. A great many of the early wells were accompanied by large volumes of gas and, at one time, an estimated 150,000,000 cubic feet of gas was being given off daily from the field. The decline of the wells was phenomenal, due in large part to close spacing, and after January, 1920, many of the wells completed had insufficient gas pressure to cause a natural flow. The available evidence seems to indicate that the gas in this field was uniformly rich in gasoline. Accordingly, the waste, accurate data concerning which cannot be obtained, must have run into millions of gallons.

That this waste, for the most part, was unavoidable under the circumstances seems clear — the circumstances being a race for oil under a highly competitive system, with the unit of exploitation so small that the wells on one property might readily drain the oil from under an adjoining tract.

[1] Information was secured by the writer from the lease manager at the well in the spring of 1920.

This required that each individual or company drain the oil from under his land as quickly as possible and that the drilling programme for the entire acreage be completed at the earliest possible date. Such a programme in turn necessitated simultaneous completion of wells, an uncontrolled gas flow, a rapid decline of gas pressure and early exhaustion of the field. To have built a sufficient number of natural-gas gasoline plants with a capacity capable of handling the entire volume of gas being produced at one time, might well have proven, physically, an impossible task. It would have meant financial disaster to any one who might have had the hardihood to have made the attempt.

CHAPTER X

WASTE BY FLOODING OIL SANDS

THE presence of underground water in contact with an oil sand may result in curtailment of gas flow, a diminished natural-gas gasoline production, a diminished oil production, an increased cost of lifting the oil, and a poorer quality of oil due to its emulsification with the water.[1] These five factors have made the water problem a very serious one. It would not seem to be an exaggeration to say that underground water is the greatest single cause of waste in oil production, and that it has come to be regarded by the oil operator as the greatest possible source of financial loss. Such wastes are not confined to any one section of the country but have made their appearance wherever oil production has been carried on.

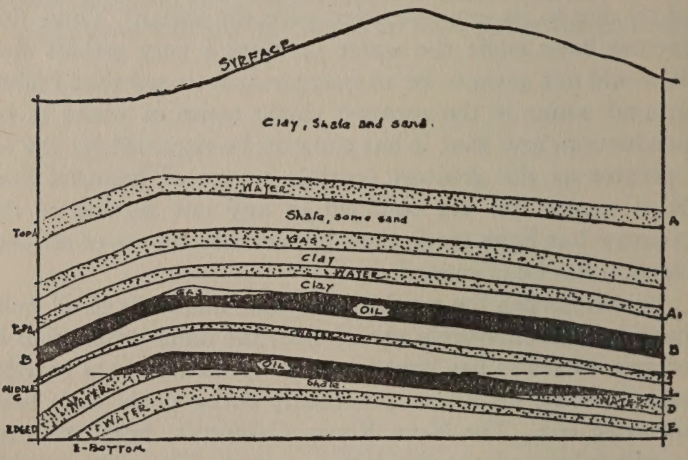
So serious has the trouble been that hundreds of oil wells have been prematurely abandoned, the daily production in certain localities has been lessened by thousands of barrels, and, in some instances, practically entire pools have been drowned out. The Kern River, California, field offers an excellent example in this latter respect. There the trouble became so serious that certain portions of the field, yielding prolific production before the appearance of water in the wells, have been completely ruined and abandoned. The Homer, Louisiana, pool offers a similar illustration. This field started off with wells yielding thousands of barrels; water soon appeared and simultaneously the wells showed a large decline.

Such general illustrations might be multiplied indefinitely, but the important consideration is not so much the extent of

[1] Ambrose, A. W., *Underground Conditions in Oil Fields*, Bulletin 195 (U.S. Bureau of Mines, 1920), pp. 74–75.

the waste, as it is its underlying cause and the possibility of its elimination. This necessitates a further brief review of the underground geological and physical distribution of waters. Waters found in connection with oil-field operations are commonly divided into four classes on a basis of source and location — top water, bottom water, intermediate water, and edge water.[1] Ambrose defines top water as that lying in a sand or other water-bearing formation above the

FIGURE XIX. HYPOTHETICAL SKETCH TO SHOW DIFFERENT WATER SANDS



A and A_1, top waters; *B*, oil and gas sand; *C*, middle water; *D*, edge water; *E*, bottom water. (After Ambrose, *Underground Conditions in Oil Fields*, United States Bureau of Mines, 1921, Bulletin 195, p. 80.)

oil-producing horizons; bottom water as that occurring below the oil-producing formation in a different stratum usually separated from the oil by a 'break' of shale or other impervious formation; intermediate water as that occurring in a sand located between two or more productive oil horizons; and edge water as that occurring in the down slope of an oil or gas-bearing stratum. (See Figure XIX.) Available technology and mechanics, if properly applied,

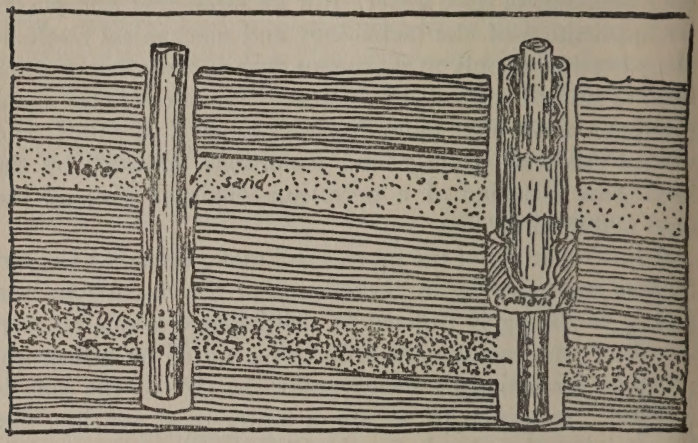
[1] Ambrose, *op. cit.*, pp. 79–80.

may eliminate the danger from the first three of these sources, and may do much to mitigate the losses from the encroachment of edge water. But an intelligent and effective application of the technology and mechanical methodology is possible only to the extent that coöperation or some form of unified control is substituted for unrestricted competition. Scientific operation demands a detailed and careful study of underground conditions, followed by the intelligent direction of a petroleum engineer with all the data before him.

A further study of the matter will make the point clearer. As was suggested in an earlier part of the discussion, iron piping or casing is utilized in drilling operations to shut off water, the casing ordinarily being seated on a firm impervious formation at which point the size of the hole is reduced. In order to secure a water-tight seating, the lowest joint of casing is fitted with a casing shoe, which is forced down into the impervious stratum by the weight of the string of casing or in the absence of a sufficiently tight formation the same object may be more effectually accomplished by setting the bottom of the casing in cement. (See Figures XX and XXI.)

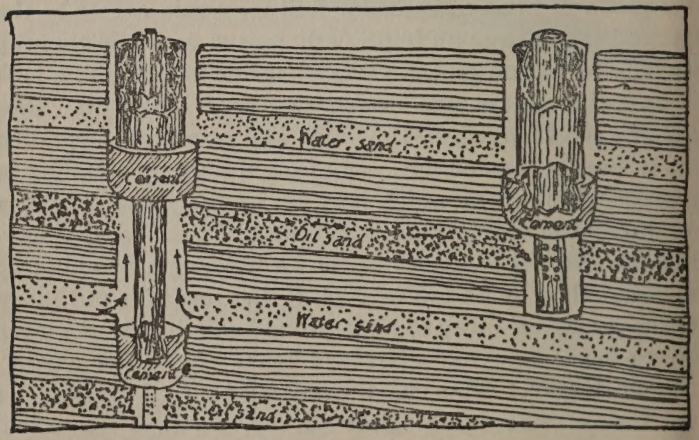
Top water in any particular well may gain access to the oil sand either from an improperly seated casing in the well itself or by migration from a neighboring well due to a lack of coördination in the casing depths of the two. (See Figures XXII and XXIII.) Any well of a group standing alone may be water-tight. Any well of a group standing in juxtaposition, all of which may be properly cased from a mechanical and geological standpoint, if considered singly, may furnish the source of water for flooding a neighboring well and thereby an entire pool, if due regard is not given to the geological unity of underground conditions. A glance at the accompanying chart will make this point clearer. (Figure XXIV.) This chart, prepared by Carl H. Beal for the United States Geological Survey, portrays the actual underground water condition of the Cushing pool and shows

FIGURE XX. SKETCH SHOWING ENTRANCE OF WATER INTO OIL SAND AND ITS MIGRATION TO A PROPERLY DRILLED WELL, FROM THE USE OF ONLY ONE STRING OF CASING IN FIRST WELL



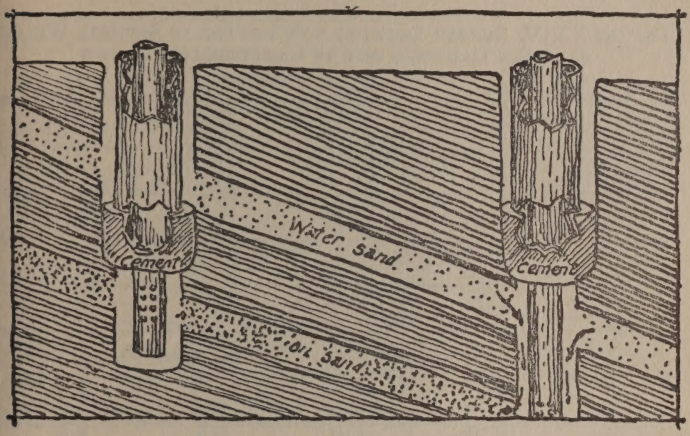
(After Bulletin 82, p. 13, California State Mining Bureau.)

FIGURE XXI. SKETCH SHOWING ENTRANCE OF WATER INTO A PROPERLY DRILLED WELL BECAUSE A NEIGHBORING WELL ENTERED A DEEPER OIL SAND WITHOUT INSERTING AN EXTRA STRING OF CASING TO PROTECT THE FIRST SAND



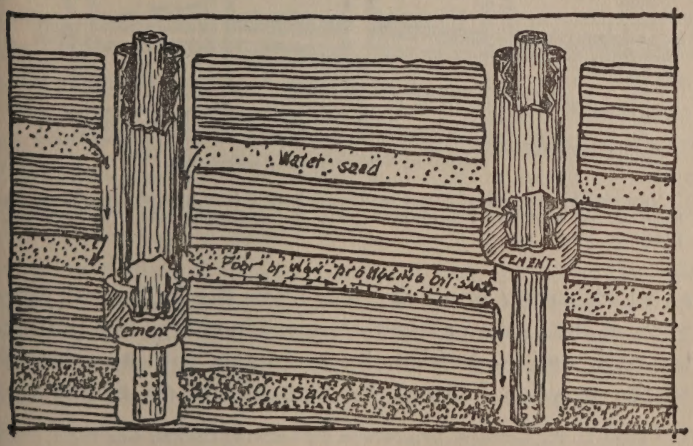
(After Bulletin 82, p. 15, California State Mining Bureau.)

FIGURE XXII. SKETCH SHOWING ENTRANCE OF WATER BECAUSE SHUT-OFF WAS MADE AT THE SAME DEPTH IN TWO WELLS WITHOUT CONSIDERATION OF THE FACT THAT STRATA MOST FREQUENTLY DO NOT LIE PARALLEL TO THE GROUND SURFACE



(After Bulletin 82, p. 14, California State Mining Bureau.)

FIGURE XXIII. SKETCH SHOWING ENTRANCE OF WATER FROM LACK OF UNIFORMITY OF DISTANCE OF SHUT-OFF BELOW WATER SANDS WHEN TWO WELLS PENETRATE THE SAME STRATA. IF THERE WERE ONLY ONE WELL, EITHER ONE WOULD PROBABLY BE IN GOOD CONDITION

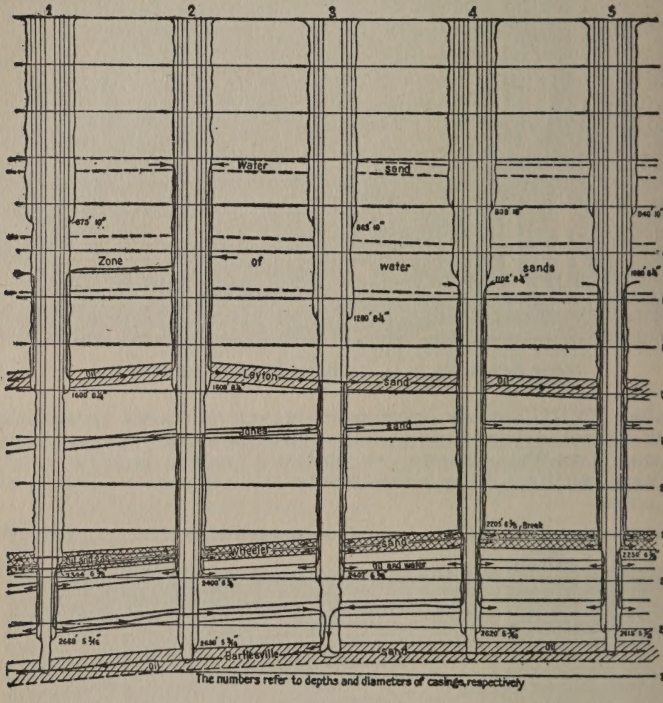


(After Bulletin 82, p. 14, California State Mining Bureau.)

how oil sands were flooded in certain areas by reason of lack of harmonious adjustment of casing depths.[1]

It should be borne in mind that in field practice the depth

FIGURE XXIV. SKETCH SHOWING HOW THE OIL IN SEVERAL WELLS HAS BEEN DROWNED OUT BY UNSYSTEMATIC CASING

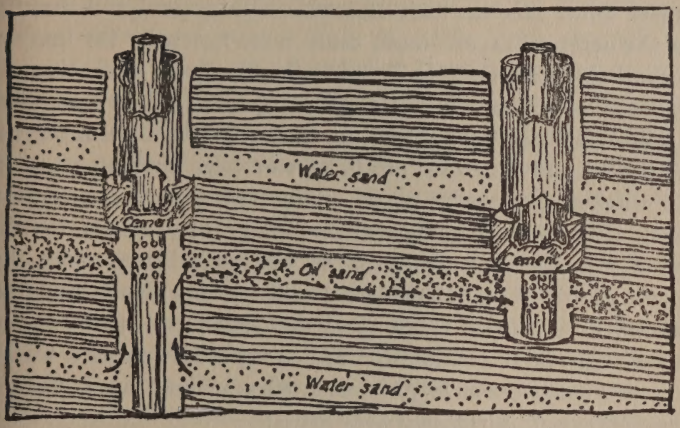


Compiled for the United States Geological Survey from logs of five wells along a line in one of the most productive parts of the Cushing field. (Bulletin 658, p. xi.)

at which casing is set depends upon the individual judgment of the driller or superintendent in charge of a particular well, and is decided, by and large, with no reference to the practice followed by competitors on neighboring

[1] Beal, C. H., *Geologic Structure in the Cushing Oil and Gas Field, Oklahoma*, Bulletin 658 (U.S. Geological Survey, 1917), p. 44, plate XI.

FIGURE XXV. SKETCH SHOWING ENTRANCE OF WATER INTO A PROPERLY DRILLED WELL BECAUSE A NEIGHBORING WELL DRILLED INTO A WATER-BEARING SAND BELOW THE OIL SAND WITHOUT PLUGGING THE LOWER PART OF THE HOLE



(After Bulletin 82, p. 15, California State Mining Bureau.)

tracts. The disastrous results are shown in Figure XXIV, on page 192.

Bottom water is allowed to enter an oil sand by drilling too deep. It might occur in the early development of a pool under any form of control, for the thickness of an oil-producing stratum in a particular locality cannot be determined without first drilling through it. When bottom water occurs in a field it is ordinarily separated by a thin hard formation known to the driller as a shell or break. As long as this shell is preserved intact it acts as a seal shutting off the water. (See Figure XXV.) Unless great care is exercised in drilling into an oil sand, it may be gone through and the shell penetrated before its location is exactly determined and the water allowed to enter the oil sand. There is always a great incentive to puncture the sand through its entire thickness, thereby opening a greater saturated porous space, and increasing the oil production. Under a competitive race in oil extraction, the incentive is

especially strong. To avoid drilling through the oil sand and into the water, it is necessary to determine the exact distance from the top of the water to the base of the oil zone. Once this has been determined in a pool and the dip of the stratum ascertained, there is no necessity for further puncturing the shell in neighboring wells.[1] Here the advantage of coöperation is readily apparent. The successful application of technology, in this regard, depends upon access to and a careful study of well-kept drilling records. Through a coöperative study of the well records of adjacent wells it is possible to determine with great precision the direction and extent of the dip of the underlying rocks, the exact depth of the various formations, the depth and the thickness of the oil sands, and the depth at which bottom water may be encountered. The competitive system works at cross-purposes to all this, with what serious consequences the following illustration sets forth:

A well was completed on the Peoples farm in Eastland County, Texas, in September, 1919. The well extended the Pleasant Grove Pool about a half mile to the southeast. The top of the oil sand was encountered at a depth of 3563 feet and the first twenty-four hours' production yielded 1200 barrels of oil. Although other wells had been completed within one half mile, information in regard to underground conditions was not available. Therefore, the well was drilled through an oil sand, 19 feet in thickness, through a thin hard shell and into bottom water. Its production dropped overnight to 329 barrels of oil accompanied by considerable water. From that date until the spring of 1920, the well continued to produce water, the amount of oil steadily decreasing. On March 28 its production of oil was only 60 barrels.

Prior to the completion of the above-mentioned well, a small company had secured a narrow 10-acre excess strip, left over through a mistake in the survey of 80 acres, the property of E. R. Hanks, which had been leased to one of

[1] Ambrose, *op. cit.*, pp. 79 *et seq.*

the largest companies operating in this field. This strip was about three fourths of a mile in length and about 60 feet in width. The well on the 10-acre strip was completed on November 15, 1919, with an estimated initial daily production of 1500 barrels. The pipe-line runs showed a settled daily average for the period from November 15 to December 1, of 500 barrels. The well was located approximately one half mile from other producers, and accordingly, showed an unusually steady daily production, with no decline. On the contrary, the daily average increased to 600 barrels during December, to 700 barrels during January, and to 800 barrels by February 9. Immediately after its completion, a third company had begun drilling just 60 feet to the north on the E. A. Allen property, and the second company 60 feet to the south on the Hanks property. The well to the north was completed on February 10, with an initial production of approximately 1000 barrels. Immediately, the well on the 10-acre strip declined to about 400 barrels. The well to the south encountered the oil sand February 17, getting a small production. This well robbed the well on the strip of its gas pressure and the latter ceased to flow. The well to the north encountered the oil sand at 3512 feet and drilled to a total depth of 3521 feet. The well to the south struck the top of the sand at 3515 feet, drilled through it at 3528 feet, and continued to drill, presumably with an idea of increasing the production. At a depth of 3561 feet salt water was encountered and the three wells were immediately flooded. The well on the strip has not produced a barrel of oil since, but has been plugged and abandoned. The well to the north began making salt water immediately, its oil production dropping about 100 barrels overnight. The decline continued and within five days its production had dropped from almost 1000 barrels to less than 100 barrels. By May, 1920, the well was making 30 barrels of oil, had been placed on the pump and was still making salt water.

The first well drilled (on the 10-acre strip) was constructed

at a cost of approximately $50,000 and yielded during a lifetime of three months and four days, 60,945 barrels of oil with a commercial value in round numbers of $180,000. At the time the first offset was completed, at a distance of 60 feet, the well was still making 800 barrels per day. Its total production, after the completion of the well to the north, was 4200 barrels; since the well to the south was completed the 10-acre strip has never produced. The cost of the two additional offsets was about $100,000 and their total yield during the three months after completion was approximately 15,000 barrels with a commercial value of $45,000. About two thirds of this amount had been produced by the well to the north before the salt water had been encountered.

Edge water, the water found in an oil sand in the lower portion of the folds, according to Mr. Ambrose, presents the most important problem in production engineering.[1] He describes in detail, how, as the oil is drawn from the sand, the advancing underground water may entrap the oil, thereby preventing complete extraction.[2] (See Figure XXVI.) He suggests the following methods for solving the problem:

1. 'Force compressed air into those wells nearest the edge water, thus holding back the water, while permitting increased production in the wells up slope.'

2. 'Keep the edge wells pumping in order to remove the water from the sand as rapidly as it encroaches.'

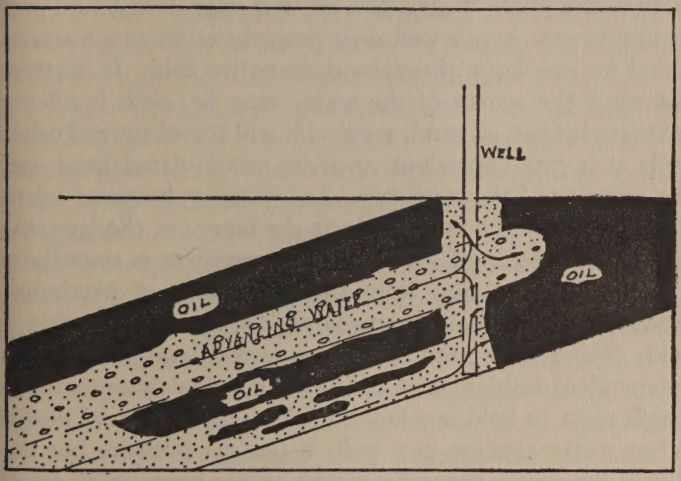
Excellent as the above suggestions may be, the competitive system renders any attempt at their application impracticable and only to the extent that a departure is made from such a system, either in the direction of voluntary coöperation, consolidation or Government control, can the situation be remedied.

[1] Ambrose, *op. cit.*, pp. 145–146.

[2] It should be noted at this point that a rapid exhaustion of gas through a close spacing of wells greatly increases the danger of a pool's being flooded by edge water. Water migrates more readily than oil and, as the pressure is rapidly withdrawn, may entrap the oil in the sands and drown out the pool.

Air under pressure in the underground pores of the rocks has little respect for property lines and the result of the first experiment suggested above may serve only to benefit a competitor on an adjoining lease at the expense of the individual who initiates the test. Likewise, in pumping edge-water wells where these are separated from oil-producing wells by a property line, the expense normally falls

FIGURE XXVI. SKETCH SHOWING HOW FLUID ADVANCES MOST RAPIDLY THROUGH THE COARSE SANDS, AND THE WATER THUS TRAPS THE OIL IN THE FINE TIGHT SAND



(After Ambrose, *op. cit.*, p. 71.)

to the owner of the water wells; the profits go to the owner of the oil wells. Such a division of income and outgo rarely furnishes a sufficient incentive to spur the owner of the water wells into action and the water is apt to be permitted to follow its own course unobstructed.

The Mexia, Texas, oil field affords one of the most recent examples of the gravity of the water problem in oil-field development. It also illustrates the manner in which the competitive system accentuates and magnifies the evils involved and shows how it renders difficult the application

of a remedy. This field was discovered in 1921 and developments proceeded with customary rapidity. Natural-gas pressure was the motive force which brought the oil to the surface. The initial production of many wells was gratifyingly high, in some instances running into the thousands of barrels per day. Water soon made its appearance in a number of wells and with the extension of the field became an increasingly serious problem. As the foregoing discussion has indicated, the water problem cannot be isolated. It is essentially a problem connected with the development of an entire pool. Water, like oil, is a migratory liquid and its appearance in one well may properly serve as a warning signal for operators throughout an entire field. It matters not what the source of the water may be, once it effects entrance into an oil sand, some of it will travel toward other wells at a rate dependent upon its accumulated head and the porosity of the structure. An operator, however scientific and careful he may be, is at the mercy of the ignorant and careless competitor. The water problem is essentially a group problem and from the standpoint of maximum production and profit concerns all the operators within a field. Nevertheless, the problem is generally attacked in an independent fashion, each operator adopting those methods which seem to hold out hopes of greatest individual profit. When water appears in a well, if the gas pressure has declined, the well is generally placed on the pump in an effort to pump off the accumulated water and, with the water, the oil. This method of handling the difficulty results in greatly increased lifting costs, and the water often cuts or emulsifies the oil. This may necessitate special treatment under a dehydration process, which further increases the expense and causes additional losses by evaporation. Swabbing is often resorted to, and, although somewhat more expensive than pumping, is apt to yield a considerably higher daily recovery of oil. While it may result in quicker and greater profits to individuals first to adopt it, it does not solve the water problem and is apt to prove detrimental to pro-

duction as a whole. It is undoubtedly harmful to any pool when water appears before the potential natural oil recovery has been obtained. Oil is forced into the wells by gas pressure. Swabbing draws off an excessive amount of gas per volume of oil produced, and it may thereby reduce the ultimate recovery. After a well has been swabbed for a while it may be necessary to continue swabbing operations, however, since the oil may refuse to flow into the well except by continued swabbing.

So serious had the water problem become in the Mexia field by the summer of 1922 that the Bureau of Mines offered its services in an endeavor to remedy the situation. With the appearance of water in a number of sections of the field individual well production had fallen off and some wells had been abandoned. Other wells were fast becoming largely water wells, and there seemed danger of certain pools being rendered prematurely unproductive. An investigation was undertaken by the Dallas, Texas, office of the Bureau and a preliminary report issued in August, 1922. This report gave tabulated results on 133 wells. The selection of wells was made because 'casual observation indicated considerable water in production and infiltration from different sources.' The investigation disclosed the fact that 91 of the wells were producing some water with the oil, eleven wells had been abandoned, and only 21 were making clean oil. This preliminary report indicates that much of the water trouble in the area covered was due to infiltration of top water through defective casing. Water had migrated in a number of instances from the offending well to neighboring wells. It also indicates that a considerable proportion of the water produced with the oil was edge water. These general conclusions are embodied in the report. Specific suggestions are made in a number of instances for proper remedial measures. But the prime interest attached to the report from our viewpoint is that it indicates clearly the impossibility of adequately handling the water problem under the present haphazard

methods of production. The chief difficulty is not due to a paucity of petroleum technology. Rather the difficulty lies in applying remedies available under existing technique. We do not mean to imply that the detection of the source of underground water is a simple matter, nor that once the water is located it can easily be excluded. On the contrary, both problems present a task worthy of the effort of the most competent engineering skill. But the fundamental obstacle is encountered in the lack of sufficient data on which to diagnose properly the source of the trouble. A scientific study of the problem is dependent upon careful and well-kept drilling records, setting forth the character and thickness of strata punctured, casing depths, depth to water horizons, etc. Water analysis setting forth the character and percentage of mineral content of the various waters encountered are extremely useful in isolating the source of the offending fluid. Temperature is often an index to the location of trouble, since lower waters quite uniformly manifest higher temperatures than upper waters. In a group of pumping wells, fluid levels and production data setting forth the daily barrelage of oil and water may afford aid in isolating the seat of trouble. The preliminary report of the Bureau of Mines is replete with illustrations of the inaccuracy and inadequacy of well logs, the lack of production and drilling data, improper plugging of wells and improper abandonments.

Soon after the issue of this first report by the Bureau of Mines, a second investigation was begun by the same organization to determine the source of water in the Fish Pond Area of the same field. A preliminary report covering this investigation was issued in the early fall of 1922. In the area considered top water was apparently offending only to a minor extent. There was no evidence to show that the sand and water conditions of this area corresponded to those found in the other area investigated. In some wells near the limits of production edge water had been encountered, but the chief source of trouble seems to have been

from bottom water. This opinion is in harmony with that held by Mr. Julius Fohs, prominent oil geologist, who was in large part responsible for the opening of this field and who has followed closely developments therein. According to Mr. Fohs [1] a shale break separates the lower oil sand from an underlying water stratum, and the chief inlet for water has been from wells drilled too deep through the shale break into the water horizon. As has been previously pointed out, there is a strong temptation on the part of the operator to drill a well through the entire thickness of the oil sand, since by opening a greater thickness of the oil-saturated stratum, the production of the well may show a decided increase. A few more feet of depth may result in a few more hundred barrels of oil per day. With underground conditions as they are in the Mexia field, where production is from several different levels, the incentive for increasing the depth of a well is particularly strong. In the absence of accurately recorded and carefully coördinated drilling records the danger of operation is increased manyfold. Developments in the Mexia field render eloquent testimony to the disastrous results of customary haphazard methods.

The second report of the Bureau of Mines contains a detailed analysis of water conditions in some 130 wells. The report sets forth the temporary character of the conclusions reached due to the difficulties encountered from inaccurate and incomplete records. It makes, however, a number of specific recommendations. In some instances the recommendations have been carried out under the supervision of the Bureau. The results obtained are interesting and significant. The accompanying map (see Figure XXVII) indicates the approximate water production in barrels in September, 1922, of a few of the wells under investigation. Well No. 1 on the Freeman tract, operated by the J. K. Hughes Development Company, at the outset produced large quantities of water. The well had been

[1] Personal communication with the writer.

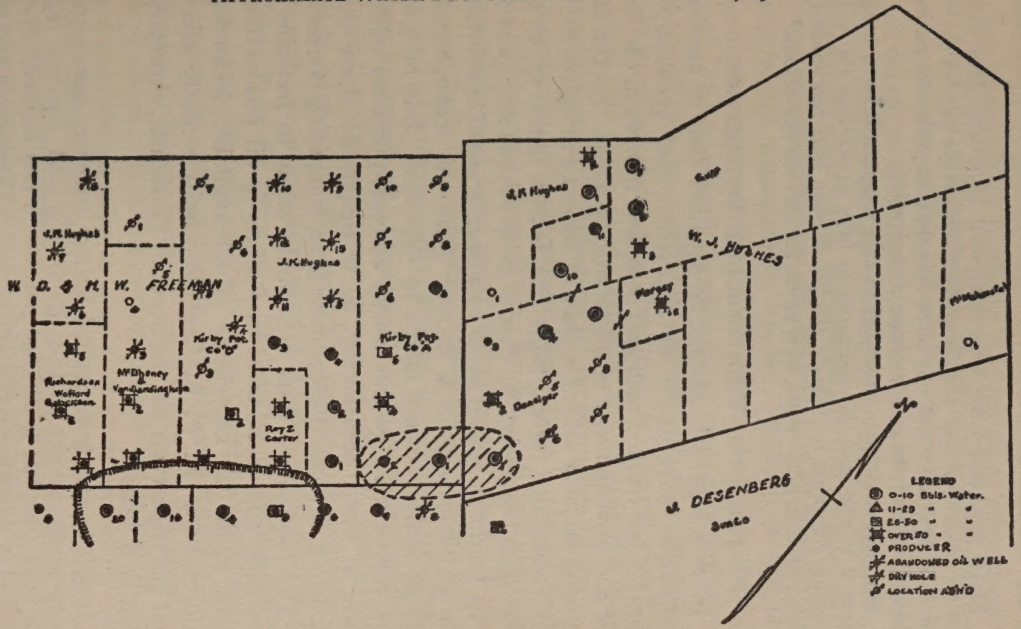
drilled to a total depth of 3090 feet. The water zone had been encountered at a depth of 3073 feet. An attempt to shut off the water with a lead plug failed. On September 25 the well was plugged back with cement under pressure to 3068 feet. After plugging, the well produced practically no water and the oil production increased 100 per cent.[1] The performance of the wells on the adjoining Roy I. Carter lease has shown that the plugged well on the Hughes lease had been a serious offender. Before the Hughes well was plugged the Carter well No. 1 produced 90 per cent water and 10 per cent oil. Carter No. 2 produced 75 per cent water and 25 per cent oil. During the 24 hours that the Hughes well was held under pressure both Carter wells produced 100 per cent water. Immediately afterward it was noted that the volume of water produced by the Carter was decreasing and the volume of oil increasing. Fifteen days later the water production of the Carter No. 1 well had decreased 80 per cent and the oil production had increased 20 per cent. Oil production on Carter No. 2 showed an increase of 100 per cent and water production a decline of 33⅓ per cent.

According to the Bureau's report, most of the offending wells in this neighborhood had been drilled into bottom water. In its concluding remarks the report states that it has been 'demonstrated that the lower water can be shut off in these wells at no great cost, by plugging with cement placed under pressure. . . . It is believed that much production which would otherwise be lost can be saved and the life of this portion of the field can be prolonged at a comparatively small cost, by working along the lines indicated. At many wells the difference between the cost of pumping water with the oil and treating it afterward and that of pumping clean oil would repay the cost of repairing the wells in a short time.'[2]

[1] U.S. Bureau of Mines, *Report on the Fish Pond Area, Mexia Field*, p. 8.

[2] *Ibid.*, p. 15.

FIGURE XXVII. MAP OF A PORTION OF THE FISHPOND AREA, MEXIA, TEXAS, FIELD, SHOWING APPROXIMATE WATER PRODUCTION AS OF SEPTEMBER, 1922



(Data from United States Bureau of Mines, Dallas, Texas, Office.)

Attention is called to the difficulty of accurate diagnosis in the absence of records.

Much time and labor were consumed in getting data together, not on account of any unwillingness to coöperate but for the reason that the operators did not have complete or collected records on the drilling and the performance of their wells.

The time and labor expended in this report will have been well spent if it will lead the operators to fully appreciate the value of keeping complete records of the production and mechanical condition of individual wells, as a guide for further operations.[1]

Guarding Technological Information

In this regard it should be recalled that a number of companies have come to appreciate the pecuniary advantages of trained men and complete records in the search for and development of oil-producing areas. As the larger companies have added a staff of expert geologists to their field and office forces, there has been a tendency to place petroleum engineers in charge of development operations. This tendency would seem to augur a possible solution of the problems set forth above. With the technologists in charge improvements might be expected. But here again the competitive system works at cross-purposes with the ends in view, occasioning, as it frequently does, careful guarding of technological data from competing concerns.

The discussion, thus far, would seem to indicate that scientific and economical operations in oil production depend upon full knowledge of all available technological information. R. P. McLaughlin, until recently chief oil and gas supervisor for the State of California, expresses the idea as follows:[2]

It will be clearly recognized by any reasoning person that to economically extract oil from its underground reservoir requires the most complete knowledge possible on two subjects: first, the natural or geological conditions governing the creation and preser-

[1] U.S. Bureau of Mines, *op. cit.*, p. 1.

[2] McLaughlin, R. P., *First Annual Report of State Oil and Gas Supervisor*, Bulletin 73, California State Mining Bureau, p. 28.

vation of the reservoir; and second, the artificial or mechanical conditions created by efforts to drill wells and extract oil.

Under competitive methods, a pecuniary advantage is gained by the company which possesses the greatest stock of geological data. Hence there is an unwillingness on the part of companies to impart valuable information to competitors. The advantage of secrecy is readily apparent in unproven territory when operations are first begun. If oil is discovered lease values rise enormously under the competition which immediately results. Hence it is desirable to keep the matter quiet until larger holdings may be secured. Should a well prove dry, to keep this fact secret until leases may be profitably disposed of, may be equally desirable. Therefore, the less that is known about oil operations by those on the outside, the greater the opportunity for profitable operation by those on the inside.

Accordingly, oil operations have come to be shrouded with an atmosphere of mystery. Drilling data and geological information have been guarded with great care. Reports given out may be purposely unreliable. Strangers are not welcomed at drilling wells; drillers are often instructed to answer no questions. Coincident with these developments and as a direct result, there has grown up as a part of most modern large-scale oil producing concerns a scouting department, operating somewhat after the fashion of a spy system. It is the duty of a good scout to keep a careful watch upon the drilling operations of competing concerns, to secure data and report daily, weekly, and monthly to the chief scout. A new location, rig timbers on the ground, a well 'spudded in,' its completion, its initial production, and, where possible, detailed information as to its daily drilling records, the formations it encountered, its water horizons — this is the information a scout is supposed to secure, and it is largely upon these records that the petroleum technicians depend for data in directing drilling operations.

The methods of procedure of the scouts are varied. They are expected to be 'good scouts,' and are accordingly al-

lowed a liberal expense account, sufficiently flexible to cover matters of entertainment, amusement, etc. Little emphasis has been placed upon methods, however, results having come in for greater consideration. As the system has worked out in the Texas fields, scouts have come to trade information, and, in certain sections, central scouting offices have been established by the scouts in the field. These have served as a sort of clearing house. Always with limitations, however. Some of the larger companies have shown a reluctance to part freely with their more abundant data which might serve to place a competitor on an equal footing. Then, too, only certain sorts of information are freely exchanged. Detailed well records, upon which scientific drilling depends, are usually not subject to clearing-house operations. On the contrary, these are guarded with greater care, and to secure them generally necessitates the employment of a special agent, usually a member of the geological staff. This information is gotten as best it may be. Some companies have recently come to be very liberal in this regard. Others are very reluctant to give out any facts. In any event, detailed well records are generally secured on the principle of barter in kind. Certain company offices have regulations which forbid such exchange by the technicians except upon written order from the superintendent. Altogether it seems rather an awkward and unreliable method of assembling scientific data.

Such obstructive practices are matters of common knowledge in oil production and have been generally regarded as both necessary and desirable, at least as viewed by the business men in charge, who make final decisions in regard to such matters. The technicians are coming to view the matter in a somewhat different light and fail to see the good of it all. Rather, it appears to them to work out to the mutual hindrance of all parties concerned, and seems to fit into the geological and technological scheme of oil production somewhat as 'dust in the eye, or sand in the bearings.'

The following extracts from letters written in the winter and spring of 1920 by a field scout to his office chief illustrate not only the difficulties experienced in the Texas field in securing data as a basis for investment and field operations, but they place in an absurd though realistic light the haphazard methods which have characterized oil-field operations throughout the history of the industry.

A matter has come up that we all deeply regret and that is the stand that the . . . has taken. They have always been short with the boys down here and would only give their drilling report in exchange for a complete report of the field brought to their office. This has saved them the expense of keeping a scout in the field.

All the other companies operating in the field have coöperated with the scouts giving them any drilling information they have.

It would not be so bad at that, but now the . . . says to get their report we must come to the office after dark on Friday to check up. This gives them the report at their Dallas office before any other company gets it as they have a company wire to Dallas. The . . . have made the boast that they can always get the dope without having a scout, as they can scout the scouts.

I think that the matter can be fixed up at the office with the heads of the department.

. . . . . .

Work at Sipe Springs is the slowest I ever saw. Several scouts for as many different companies have been hanging around there for nearly six weeks waiting for the Humble to drill in the No. 1 Allan Dune. It is no nearer completion than it was when they set their 6⅝ casing.

. . . . . .

Business is getting better in Hill and Bell counties as there are several new companies taking leases and some are building rigs. I am sending in some new locations in Bell County. I cannot send a plot of the farm. In some of the cases I cannot tell from what corner of the farm the well is located as when a person asks for feet measurements the people in charge will tell you that they located the well right where their geologist told them they would find oil.

Not only do the foregoing extracts indicate the obstacles under which records are collected but they suggest the utter unreliability which often characterizes available data. In

field operations the task of recording the well log as drilling progresses customarily falls to the driller, who is rather appropriately known as 'the guesser' in oil-field jargon. It is he who unaided by a knowledge of the sciences of physics and chemistry, on a basis of his practical experience alone, catalogues the formations encountered, the analysis being made by the organs of sight, touch, and taste. Thickness and depths may be a matter of record, but steel-line measurements are rarely resorted to. Often days will pass without notations being made, and then the detailed account will be recorded setting forth in feet and inches the horizons encountered. This mental feat is performed by the driller somewhat after the fashion of the intermittent diarist who sets forth the daily detailed record at the close of the month. In some cases well logs have been prepared from memory by the driller after a 3000-foot hole has been completed at the end of three months' work.[1] It is on such records that the technician is often expected to rely.

Such difficulties as the technical expert encounters, should his services be secured to apply remedial measures, are the result largely of haste and ignorance. Haste is the necessary concomitant of competitive methods. Ignorance may properly be catalogued as a by-product of the same. The fate of an intelligent operator may be in the hands of an ignorant competitor whose sole justification for experimenting in the production of a limited natural resource is ownership or control of an adjoining tract. Such a situation offers little encouragement for the adoption of methods which necessitate extreme care and caution. A race in oil extraction where the reward is to the speedy throws caution

[1] S. B. Tough, engineer in charge of the Bureau of Mines' field work in the Rocky Mountain field, commenting upon the difficulty encountered in attempting to secure individual well production records, states: 'Several times when representatives of the Bureau of Mines have asked for such records, they have been told to see "Pete" or "Jim" or somebody else on the job who keeps all such information in his head.' See Tough, S. B., *Report of Operations* (U.S. Bureau of Mines, Rocky Mountain Petroleum Association, 1921), p. 49.

and care to the winds. Haste and ignorance have characterized oil-field developments since the incipiency of the industry in 1859. Their legitimate offspring has been waste. The child has grown large. The trio have played havoc with a limited natural resource.

But more fundamental than haste and ignorance as an underlying cause of the haphazard methods which have characterized oil production is the fact that the economics of the industry is out of harmony with the geological occurrence of oil. The competitive system seems ill-adapted to the predetermined, fixed conditions under which petroleum occurs in nature, the result being always and everywhere, waste and confusion. Competition necessitates practices which work at cross-purposes with the complete and economical recovery of crude petroleum. The crux of the whole matter is the arbitrary, multifold division of a geological unit in mining a migratory mineral which recognizes no property lines and transgresses the principles of ownership.

Mr. Ball sums up the situation effectively in the following words: [1]

> There is the root of the whole trouble — the small holding. Let us go back over the history of the field.
>
> We saw that as soon as the field was discovered it was leased up in small tracts. Then we saw the Smiths, the Browns, the Joneses, and the Standard Oil drilling for dear life, each trying to get the oil from under his little tract and a bit of the other fellow's before the other fellow could get it. Why? Because each tract was so small it could be drained by wells on the surrounding tracts.
>
> We saw that the race was so keen that wells were improperly drilled, that gas was allowed to waste into the air or dissipate itself through barren formations, that water was allowed to enter the oil sands and that great quantities of oil were left underground, never to be recovered. Why? Because the small holding forced each man to race his neighbor.
>
> . . . . . .
>
> Lastly, we saw the cost of production more than 300 per cent what it should have been. And what was the reason? That every

[1] Ball, Max, 'Adequate Acreage and Oil Conservation,' *Proceedings American Mining Congress*, November, 1916, pp. 322–33.

man must drill his lines as fast as might be, and must completely drill up his land at the earliest moment. Why? Because the oil under his small holding could be taken from him by wells on surrounding tracts.

Ignorance there may be, carelessness there undoubtedly is, but back of ignorance, of carelessness, of reckless, headlong methods, is the real cause — the fact that the average holding is so small that speed is the owner's sole protection. Let him be careful if he can; let him be economical if he can find a way; but careful or careless, reckless or conservative, he must be speedy if he would survive. The small holding is his master.

CHAPTER XI

THE TRANSPORTATION OF PETROLEUM AND THE COMPETITIVE SYSTEM

ALTHOUGH competition applied to the production of petroleum necessarily involves waste, once the crude product has been brought to the surface, may not the free play of competitive forces ensure maximum economy in its concentration, its processing, and its distribution? Let us consider this threefold problem, discussing in the present chapter the transportation of petroleum and in the two following chapters, its refining and marketing.

The unit of petroleum production is the individual oil well. The total domestic production is secured from several hundred thousand wells scattered over a wide area.[1] The larger portion of the total production is not used in its crude state but undergoes a refining process whereby the various constituents of the crude product are separated on a basis of volatility. While the petroleum industry turns out a wide range of commodities under a confusing multiplicity of names, there are four products of major importance — gasoline, kerosene, fuel oil, and lubricants. Production areas for the crude product are frequently remote from population centers which furnish the chief source of demand for the refined commodities. Hence, the problem of petroleum transportation assumes magnified importance. The liquidity of crude petroleum has led to the development, in response to this need of shipping facilities, of a remarkable system of transportation. The system comprises, in the main, a network of pipe lines spread over much of the country, supplemented by a specially designed tank

[1] On December 31, 1923, there were 290,100 producing oil wells in this country with an average daily production of 6.6 barrels per well. Data from United States Geological Survey.

steamer for coastwise and ocean traffic. While railroads transport a relatively small amount of petroleum in tank cars, the movement of crude petroleum, to a preponderant degree, is independent of customary transportation agencies. The problem, then, with which we are concerned in the present chapter is: Has the construction and operation of the petroleum transportation system, under competitive or quasi-competitive conditions, permitted an economical utilization of that portion of the communities' resources which it has commandeered? A study of this problem will necessitate a somewhat detailed consideration of the nature of pipe-line transportation, the cost of construction and operation of pipe lines, the location of existing facilities, the extent of duplication in equipment, the relationship between capacity and utilization of facilities, and other factors bearing upon the problem of economic efficiency. The data, covering these matters, which are presented in the following discussion are descriptive of the conditions in the Mid-Continent field, in the main prior to 1915. Since they are used, however, to illustrate certain principles, neither the element of time nor of place is important. Subsequent changes in the situation or local differences are quantitative rather than qualitative.

In the first place, it may be well to note that unlike the production of crude petroleum, which has remained since its infancy a small-scale, highly competitive enterprise, the business of pipe-line transportation is essentially a large-scale undertaking, necessitating a relatively large fixed investment, and catering, therefore, to large and secure financial organization.[1] 'A pipe line as the term is used in the oil industry is not only a line or lines of pipe, but consists of the whole plant which is used to convey oil from one

[1] While the Standard Oil interests have controlled the greater portion of pipe-line mileage since this mode of transportation came into vogue, pipe-line transportation has developed under an essentially competitive régime, i.e., under the principles of private ownership, and with a shift in production areas to the Mid-Continent territory, several independent systems of considerable magnitude have been constructed.

point to another, including initial, intermediate, and terminal tankage systems, power plants, fittings, valves, system of communication between stations and all other things necessary to safely and expeditiously transport the oil from one point to another.'[1] A pipe-line system consists of main or trunk lines extending from an oil field to refining centers, and of numerous feeder or gathering lines conveying the oil from producing wells to the trunk lines, together with the necessary storage facilities and equipment for transmission. The pipes for conveying the oil are made of steel and vary from 2 inches to 12 inches in diameter. Trunk lines are from 8 inches to 12 inches in diameter, while gathering lines vary from 2 inches to 8 inches, the greater portion being under 6 inches. Trunk lines are laid about 18 inches underground, while gathering lines generally lie on the surface. When no longer needed, the latter may be readily taken up and relaid elsewhere. Trunk lines may also be removed, although at a much greater cost.

The cost of pipe-line construction varies with a number of factors, chief among which are the size of the pipe used, the cost of material and labor, and the topography of the country. The average cost of 2196 miles of 8-inch line from the oil fields of Oklahoma, North Texas, and Northern Louisiana to Baton Rouge and the Gulf Coast exclusive of cost of pumping stations was $6389 per mile.[2]

[1] Towl, Forrest M., *Pipelines, Existing Facilities and Future Needs*, American Petroleum Institute, November 17, 1920.

[2] The writer is not unmindful of the inaccurate and unreliable nature of much available data covering costs and investment, and hence the danger of an uncritical use of material of this nature. The reader's attention is therefore directed to the source and character of the data presented in the following discussion. The data were borrowed from the Report of the Federal Trade Commission on *Pipe-Line Transportation of Petroleum* (Washington, 1916). This report was made in response to Senate Resolution No. 109, 63rd Congress, 1st Session. It is a comprehensive study of the pipe-line transportation system serving the Mid-Continent field. The Commission's problem was to determine the reasonableness of pipe-line rates in their capacity as common carriers. Data bearing on this problem were collected by the Commission's agents who made a detailed examination of the usual books of

Crude petroleum is forced through the pipes by means of pumps operated by internal combustion or steam engines. The distance between pumping stations will vary with the grade and quantity of oil to be transported and the topography of the country. The average distance between stations in the Mid-Continent field is about forty miles. In California, due to the heavier, more viscous quality of the crude, it is necessary to heat the oil to a temperature of from 150° to 160° F. before transporting it, and even then the pumping stations must be located much more closely together at an average distance of between twelve and fifteen miles. The equipment of a pumping station depends upon the quantity and quality of the oil to be handled, and upon the fuel and water supply. The equipment is generally in excess of normal demands, a reserve power being maintained to meet extra demands in case of a temporary shutdown. The construction cost of pumping stations will vary with a number of factors, among the more important of which are the general price level, the capacity and nature of the equipment utilized, and the quality of crude to be handled. According to figures presented by the Federal Trade Commission, the average cost of forty-three pumping stations in the Mid-Continent field operating 8-inch lines was $126,810.[1]

record, financial statements, etc., of the various companies. When such records did not show the detail desired, examination was made of original vouchers in the files of the different companies. Numerous difficulties were encountered, particularly in the allocation of general items of investment between the trunk and gathering lines, in determining a uniform method of calculation of depreciation and obsolescence and in reducing to a uniform system the classification of accounts. 'The information obtained from the companies' records was in such detail, however, that the items of plant investment and operating expenses can be presented in a comparable form' (p. 70). In view of the purpose for which the material was gathered and the apparent care exercised in insuring its accuracy and comparability, we feel that the material, supported as it is by theoretical considerations, furnishes a practical basis for a comparison of costs of operation of the companies included within its scope.

[1] Federal Trade Commission, *op. cit.*, p. 59.

It is necessary to maintain instant means of communication between pumping stations and along the line to report leaks and to dispatch oil. Hence, it is necessary for pipe-line companies to establish and maintain telegraph and telephone lines along their pipe lines, available for use at all times. In some cases the companies may avail themselves of facilities already existing, by utilizing the telegraph or telephone system of an adjoining railway, or by securing the privilege of stringing its own wires on the poles of such. In many cases, however, the pipe-line companies must construct their own systems of communication. The average investment in telegraph and telephone lines of 2139 miles in and from the Mid-Continent field is given by the Federal Trade Commission as $312 per mile.[1] The total investment in telegraph and telephone lines by the larger interstate pipe-line companies varied from $200,000 to $300,000 for each company.

By 1916 approximately 2200 miles of 8-inch pipe lines, with the necessary pumping stations and equipment, had been constructed in and from the Mid-Continent field at an average cost of $9000 per mile, including per-mileage cost of pumping stations and lines of communication. In the California fields the cost of a line of similar size is considerably greater. The cost of the Shell Company's trunk line, aggregating 170 miles, constructed in 1913, averaged $16,800 per mile. This greater cost is due to the heavier character of the California crude which necessitates the construction of special heating plants and the location of the pumping stations at much closer intervals.

In 1914 the crude petroleum of the Mid-Continent field was handled, in the main, by five large pipe-line systems. First and most important was the Prairie Oil and Gas Company,[2] one of the original Standard group, operating

[1] Federal Trade Commission, *op. cit.*, p. 55.

[2] At the close of 1914, a separation was made by this company of its producing and transporting business. The latter was taken over by the Prairie Pipe Line Company which was organized for this purpose. See Chapter v, p. 56.

a trunk line from the Mid-Continent field north and east to refineries at Griffith, Indiana, and Wood River, Illinois. Near Chicago the line joined with a trunk line east to the Standard refineries at Bayonne, New Jersey. Crude oil was transported over this system from the chief producing area of the United States to the chief marketing center of the country, a total distance of approximately 1500 miles. In 1914 the capacity of the trunk and gathering lines of this system was considerably greater than the combined capacity of all other interstate pipe lines that gave outlet to Oklahoma oil. Second, the Oklahoma Pipe Line Company and the Standard Oil Company of Louisiana had pipe lines which, together with the Arkansas division of the Prairie, formed a continuous system connecting the Eastern Oklahoma fields with the refineries at North Baton Rouge, Louisiana. Third, the Magnolia Pipe Line Company and the Magnolia Petroleum Company had pipe lines connecting with the Oklahoma fields which transported crude southward to refineries at Fort Worth, Texas, Corsicana, Texas, and the Gulf Coast. Fourth, the Gulf Pipe Line Company of Oklahoma, and the Gulf Pipe Line Company of Texas, formed a continuous system connecting the Eastern Oklahoma and Northern Louisiana oil fields with Port Arthur, Texas.[1] Fifth, the pipe lines of the Texas Company transported oil through its trunk-line system from the fields of Eastern Oklahoma, Northern Louisiana, and Northern Texas to Port Arthur.

Since 1914, in addition to extensions to existing systems, particularly to the North Texas fields, the network of pipe lines serving the Mid-Continent field has been augmented by the construction of several new lines. To-day the Sinclair Pipe Line Company, jointly owned by the Standard Oil Company of Indiana and the Sinclair Consolidated Oil Corporation, operates approximately 2800 miles of trunk

[1] Port Arthur is both a refining and shipping center for crude petroleum. Much of the crude is delivered to tank steamers and transported thereby to refineries located on the Atlantic Coast.

and gathering lines in the Mid-Continent area.[1] The trunk line begins in Texas and runs through the Oklahoma and Kansas fields to the refinery of the Sinclair Company at East Chicago, Indiana, practically paralleling the Prairie's line throughout most of its route. The Ozark Oil Corporation has 592 miles of trunk and gathering lines. The trunk line begins at Healdton, Oklahoma, and runs from the Oklahoma and Kansas oil-producing areas to the refinery of the Roxana Petroleum Corporation at Wood River, Illinois. The Empire Pipe Line Company has approximately 1000 miles of trunk and gathering lines serving the Kansas, Oklahoma, and Texas area; and the Pierce Pipe Line Company has 250 miles operating in Oklahoma and Texas. These companies, together with the five systems operating in 1914, transport the bulk of crude oil to-day in and from the most important oil-producing area of the United States.

As stated in the foregoing discussion, pipe-line transportation is by nature a large-scale enterprise, requiring a large fixed investment of capital. To the small man with limited financial means it offers little opportunity. In 1913 the total gross investment of the five systems operating in the Mid-Continent field was $73,560,000 in round figures.[2] By the close of 1921 the total investment of all the companies serving the Mid-Continent field in an interstate capacity had increased to $242,800,000 in round figures.[3] To-day an independent operator who desires to deliver his oil by pipe line from the Cushing, Oklahoma, pool to the Gulf Coast would require 500 miles of pipe line with a fixed investment of approximately $6,750,000; to reach the vicinity of Chicago would cost him $9,000,000; while the investment required for a single 8-inch line from the Cushing

[1] *Sinclair's Magazine*, supplement Sinclair Properties, April, 1920, p. 10.

[2] Federal Trade Commission, *op. cit.*, p. 8. These figures represent gross fixed investment in pipe-line property as shown by the books of the several companies and, according to the Commission, correspond closely with actual expenditures in pipe-line construction.

[3] Data from the Bureau of Statistics, Interstate Commerce Commission.

pool to the Atlantic Coast in the New York neighborhood would be approximately $20,000,000.

Not only does pipe-line transportation require a large fixed investment, but it also manifests a tendency toward decreasing cost up to full utilization of plant and equipment. The Federal Trade Commission in its study of costs of pipe-line transportation for the five systems serving the Mid-Continent field, found that the lowest cost for trunk-line transportation was obtained by the most highly developed pipe-line system. The lowest cost found was the cost for that company whose trunk line was operated on the largest scale, at nearest maximum capacity, with fewest pumpings with relation to the total distance oil was carried. The lowest cost per barrel was obtained by the Prairie Oil and Gas Company; and its lowest cost was obtained on that section of its lines having the greatest capacity and operated at the largest per cent of capacity. It should be recalled that during the period covered by the report this company operated the largest pipe-line system in the Mid-Continent field. The capacity of both its trunk lines and gathering lines was considerably greater than the combined capacity of all the other interstate lines that gave outlet to Oklahoma oil. The Prairie Company in 1913 showed a total net investment in trunk and gathering lines and equipment of $16,256,251, including working capital.[1] This was a little more than 37 per cent of the total net investment of the five systems engaged in interstate transportation and more than 66 per cent in excess of the next largest concern. The Prairie's main trunk line extended from Jenks, Oklahoma, to Griffith, Indiana. A branch line extended from Carrollton, Missouri, on the main line, to Wood River, Illinois. The total length of the line from Jenks to Griffith is 673.53 miles; and from Jenks to Wood River is 493.02 miles.[2] In 1913, there were 23 pumping stations on the combined lines from Jenks to Wood River and

[1] Federal Trade Commission, *op. cit.*, p. 412.
[2] *Ibid.*, p. 90.

Griffith, with varying capacities of from 20,000 to 103,000 barrels daily. The system was divided, for the purpose of cost calculation, into two divisions: the southern division, from Jenks to Humboldt, Kansas; and the northern division, from Humboldt to Griffith and Wood River. This latter section represented the most highly developed portion of the Prairie system. As originally constructed it consisted of a single 8-inch trunk line. With an increase in traffic the original line has been paralleled until by 1914 it consisted of from two to five lines varying from 8 inches to 12 inches in diameter. In 1913 this section transported 29,704,798 barrels of petroleum an average distance of 440.79 miles, or a total of 13,782,496 thousand-barrel-miles [1] of petroleum. The cost per thousand-barrel-mile was 14.3 cents. The southern division handled a total of 3,062,348 thousand-barrel-miles at an average cost of 22.5 cents per thousand-barrel-mile. Thus the northern division handled more than four times the crude handled by the southern division at about two thirds the cost per thousand-barrel-mile.

Table 5 gives the number of thousand-barrel-miles and the cost [2] per thousand-barrel-mile of trunk-line transportation for all the systems operating in the Mid-Continent field in 1911, 1912, and 1913.

Costs here tend to vary with the volume of traffic handled.[3] The Prairie's volume of business in 1913 was almost four times that of its strongest competitor; the lines were operated at approximately 99 per cent capacity; and its

[1] The thousand-barrel-mile is the unit adopted by the Federal Trade Commission for figuring costs. It represents 1000 barrels of petroleum transported one mile, or the equivalent.

[2] Costs as here presented are costs in the accountant's sense of the term and do not include interest on investment.

[3] A factor of equal importance with total volume of traffic in its effect upon costs is the capacity at which a line is operated. Unfortunately, the Commission does not give complete figures on the percentage of total capacity at which the lines were operated. Where such data are presented, however, they seem to afford a sufficient explanation for apparent exceptions to the principle that costs tend to vary with volume of traffic.

TABLE 5. THOUSAND-BARREL-MILES OF PETROLEUM TRANSPORTED BY THE MID-CONTINENT PIPE LINE SYSTEMS, AND COST OF TRANSPORTATION PER THOUSAND-BARREL-MILE, 1911–1913 *

	1911		1912		1913	
SYSTEM	Thousand-Barrel-Miles	Cost per Thousand-Barrel-Mile *Cents*	Thousand-Barrel-Miles	Cost per Thousand-Barrel-Mile *Cents*	Thousand-Barrel-Miles	Cost per Thousand-Barrel-Mile *Cents*
Prairie.....	.....	....	15,388,920,990	13.3	16,844,844,682	15.8
Oklahoma-Louisiana.	1,286,939,401	42.9	1,417,882,187	39.8	2,203,850,954	34.3
Gulf.....	4,027,720,343	32.9	4,159,531,447	36.2	4,303,902,926	36.3
Texas †.....	2,722,247,450	46.9	3,677,376,285	40.2	3,928,530,350	39.6
Magnolia...	.....	....	.....	....	1,671,166,537	44.2
Totals and averages	8,036,907,194	39.3	24,643,710,909	22.7	28,952,295,449	25.1

* Data from Federal Trade Commission, *op. cit.*, p. 415.
† Years ending June 30, 1912–1914.

cost per thousand-barrel-mile is considerably less than one half that of any other concern. In 1912 its thousand-barrel-mile cost was only 36.8 per cent of that of the Gulf system with the second lowest cost, and in 1913 it was 46.1 per cent of that of the Oklahoma-Louisiana system with the second lowest cost. The thousand-barrel-mile cost of the Gulf system increased from 32.9 cents in 1911 to 36.3 cents in 1913. In 1913 its cost was slightly higher than in 1912. Its cost in 1911 is the lowest recorded, figures for the Prairie not being given. In 1912 and 1913 its cost was second and third, respectively. The Texas Company's cost in all three years is somewhat higher than the Gulf cost. In 1911 it was approximately 25 per cent greater. In each year its volume of traffic in thousand-barrel-miles was considerably less than that of the Gulf. The two systems were approximately the same size and capacity, and the lower cost of the Gulf system as compared with the Texas was due primarily to the fact that the 'entire line of the Gulf was operated more nearly to full capacity than that of the Texas

system.'[1] The Oklahoma-Louisiana system shows the second lowest cost in 1911 and 1913 and the third lowest in 1912. In each of these years it handled the smallest volume of crude. Low cost, however, is the resultant of several factors, chief of which are the volume of traffic and the percentage of capacity at which the line is operated. The Oklahoma-Louisiana system is composed of three divisions, the Oklahoma Pipe Line Company, the Arkansas division of the Prairie Oil and Gas Company, and the Standard Oil Company of Louisiana. The low cost of this three-division system is to be accounted for chiefly by the low cost on the Louisiana end of the division. In 1913 the cost per thousand-barrel-mile on the Oklahoma section was 66.6 cents, on the Arkansas section 54.0 cents and on the Louisiana section 24.6, the average cost for the three divisions being 34.3 cents. The cost figures on the separate divisions vary annually with the percentage of total capacity at which each section was operated. For example, in 1911 the thousand-barrel-mile cost on the Oklahoma division was 67.3 cents; in 1912, 84.1 cents; in 1913, 66.6 cents. In 1911 the line was operated at 35.4 per cent of its working capacity; in 1912 at 28 per cent capacity; and in 1913 at 42.2 per cent. The figures for the Arkansas division show similar fluctuations with variations in the percentage of capacity at which the lines were operated. In 1911, with the line operating at 35.4 per cent of its capacity, the cost per thousand-barrel-mile was 58.1 cents; in 1912, at 26.4 per cent capacity the cost increased to 65.1 cents; and in 1913, with working capacity increased to 34.2 per cent, the cost per thousand-barrel-mile dropped to 54.0 cents.[2]

Table 6 brings out the fact that an increase in the volume of petroleum transported is not accompanied by a corresponding increase in the fixed investment.

It will be noted that the Prairie Oil and Gas Company's total thousand-barrel-miles of traffic was almost four times

[1] Federal Trade Commission, *op. cit.*, p. 416.
[2] *Ibid.*, p. 440.

TABLE 6. THOUSAND-BARREL-MILES, TOTAL NET INVESTMENT, NET INVESTMENT PER THOUSAND-BARREL-MILE, AND COST PER THOUSAND-BARREL-MILE FOR THE PIPE LINES SERVING THE MID-CONTINENT FIELD, 1913

SYSTEM	Thousand-Barrel-Miles	Net Investment in Trunk Lines Including Estimated Working Capital	Investment per Thousand-Barrel-Mile	Cost per Thousand-Barrel-Mile
Prairie.....	16,844,844.6	$13,749,233†	$0.768*	$0.158*
Oklahoma-Louisiana....	2,203,850.9	5,873,434‡	2.666‡	.343‡
Gulf.....	4,303,902.9	6,189,333‡	1.438‡	.363‡
Texas.....	3,928,530.3	7,430,310‡	1.891‡	.396‡
Magnolia.....	1,671,166.5	..... §	2.183*	.442*

* Federal Trade Commission, *op. cit.*, p. 437. † *Ibid.*, p. 426.
‡ *Ibid.*, p. 438. § Figure not available.

that of its largest competitor; its total investment was less than twice that of the company having the second largest investment, however, while its investment per thousand-barrel-miles was markedly less than that of any other concern. With an investment of only 76.8 cents per thousand-barrel-mile, its cost per thousand-barrel-mile in 1913 was only 15.8 cents. The Oklahoma-Louisiana system with the lowest total investment but with the largest investment per thousand-barrel-mile, $2.67, showed the greatest cost per thousand-barrel-mile, 34.3 cents, more than twice that of the Prairie.

Table 7 shows the relationship between net investments, volume of traffic, costs, and rate of earnings.

It will be noted that the rate of earnings and net earnings per thousand-barrel-mile vary inversely as the net investment per thousand-barrel-mile. In each of the three years the Gulf Company shows the lowest net investment per thousand-barrel-mile and the largest rate of earnings on net investments. The Oklahoma-Louisiana system shows with equal consistency the largest net investment per thousand-barrel-mile for each year with the lowest net earnings per thousand-barrel-mile and the lowest rate of earnings. For

TABLE 7. TRUNK-LINE NET INVESTMENT AND EARNINGS PER THOUSAND-BARREL-MILE, FOR THE OKLAHOMA-LOUISIANA, GULF, AND TEXAS SYSTEMS, 1911–1913*

SYSTEM	1000-Barrel-Miles	Net Investment		Gross Earnings per 1000-Barrel-Mile	Cost per 1000-Barrel-Mile	Net Earnings per 1000-Barrel-Mile	Rate of Earnings *Per Cent*
		Amount	Per 1000-Barrel-Mile				
1911							
Okla.-La..	1,286,939,401	$4,687,787.95	$3.643	$0.716	$0.429	$0.286	7.86
Gulf.....	4,027,720,343	6,188,833.64	1.537	.892	.329	.563	36.63
Texas....	2,722,247,450	7,806,979.14	2.868	.816	.469	.346	12.08
Total..	8,036,907,194	$18,683,600.73	$2.325	$0.838	$0.393	$0.445	19.15
1912							
Okla.-La..	1,417,882,187	$4,809,296.53	$3.393	$0.744	$0.398	$0.347	10.22
Gulf.....	4,159,531,447	6,329,915.21	1.522	.871	.362	.508	33.41
Texas....	3,677,376,285	7,620,808.36	2.072	.839	.403	.436	21.04
Total..	9,254,789,918	$18,760,020.10	$2.027	$0.839	$0.384	$0.455	22.44
1913							
Okla.-La..	2,203,850,955	$5,873,433.69	$2.665	$0.773	$0.343	$0.430	16.14
Gulf.....	4,303,902,926	6,189,332.71	1.438	.910	.363	.548	38.07
Texas....	3,928,530,350	7,430,310.22	1.891	.831	.396	.435	23.00
Total..	10,436,284,231	$19,493,076.62	$1.868	$0.852	$0.371	$0.480	25.72

* Data from Federal Trade Commission, *op. cit.*, p. 438.

each system the number of thousand-barrel-miles increased in each successive year while the investment per thousand-barrel-mile decreased. The total for the three systems shows a slight increase in investment each year, but a considerable increase in the number of thousand-barrel-miles, and hence a decrease each year in the investment per thousand-barrel-mile. In other words, the new traffic was handled with a less than proportionate increase in investment. The result was that the totals for the three systems show an increase each year in the gross earnings per thousand-barrel-mile, a decrease in the costs per thousand-barrel-mile, a marked increase in the net earnings per thousand-barrel-mile, and an increase in the rate of earnings.

The above analysis is convincing. In the transportation of petroleum large-scale operations with full utilization of

plant and equipment mean economy. The reason is not difficult to ascertain. A considerable proportion of both construction and operating expenses are of the nature of fixed or constant charges, irrespective of volume of business transacted. The expenses connected with the location of route, the purchase of right-of-way, surveying, construction of telegraph lines, etc., vary slightly, if at all, with the size of the plant constructed. Once a line is in operation, many of the charges are supplementary and vary little with the volume of traffic. Expenses for labor, superintendence, ground rents, depreciation, and most of the general expenses remain about the same whether the line is operated at full or partial capacity. As volume of traffic increases a point may be reached where additional equipment may be necessary; but in this case existing pumping stations may be economically utilized to handle the increased traffic by the construction of loops or parallel lines, the additional traffic being handled under the principle of diminishing costs. The fact that the Prairie obtained the lowest per-unit costs in 1911 and 1912 is to be accounted for by the fact that it was the most highly developed system and was operated most nearly at full capacity. A conservative policy of construction had been pursued as the traffic had increased, existing lines had been paralleled, until there were from three to five lines between most stations, and the lines were operated at about 99 per cent capacity. With this system, the Prairie was able to pump from three to five times as much oil as could have been pumped through a single line system, with the same number of pumping stations, and at a greatly reduced cost.

Competition among relatively small pipe-line transportation companies whose lines serve the same areas and traverse the same routes necessarily involves a considerable element of waste which rests as an unnecessary tax upon the communities' resources. The extent of this waste, as our pipe-line systems have developed, cannot be accurately calculated with available data, but an examination

of the routes of the major pipe lines serving the Mid-Continent field indicates waste of considerable magnitude. At the close of 1915 there were three outlets for Mid-Continent oil to the Gulf Coast of Texas — the Gulf System, the Texas System, and the Magnolia System. The main trunk lines of both the Gulf and Texas companies had as their origin Bartlesville, Oklahoma, and their destination Port Arthur, Texas. The routes traversed were somewhat different but, en route, each line served refineries in the same neighborhood, the Gulf Company at Fort Worth and the Texas Company at Dallas. The Texas Company's line (exclusive of the Electra-Dallas branch) totaled 603 miles in length, and included seventeen pumping stations. For 89 miles the line was composed of two 6-inch pipes; for 50 miles, of two 8-inch pipes; and the balance (464 miles) of a single 8-inch line.[1] The Gulf Company's line was 508 miles long, and included eighteen pumping stations. For the first 52 miles the line consisted of a single 6-inch pipe; for 314 miles the line consisted of a single 8-inch pipe; for 12 miles it consisted of a double 8-inch pipe; and throughout 130 miles, the remaining length of the line, the line was doubled with a 6-inch and an 8-inch pipe.[2] Each of the companies had branch lines extending from the North Louisiana fields to the Gulf Coast, for a distance of over 200 miles. While the Gulf Company's line was looped throughout the greater distance, the Texas Company's was single 8-inch pipe throughout most of its extent. The origin and destination of the lines were common, but separate routes and equipment were used. From the Electra field in North Texas the Texas Company had a 6-inch line extending to Dallas where it joined with the main 8-inch line from Bartlesville. From the Electra field the Magnolia Petroleum Company had an 8-inch line extending to Sabine, Texas, on the coast, a distance of 479 miles. This line paralleled the Texas Company's line throughout its entire

[1] Federal Trade Commission, *op. cit.*, p. 290.
[2] *Ibid.*, pp. 205 and 233.

extent, but obviously under a competitive régime separate facilities were necessarily used by each. Had these pipe-line facilities giving outlet to the Mid-Continent field been constructed under some sort of unified control instead of under the uncoördinated methods of competition the development of a transportation system adequate to handle the traffic at a greatly reduced cost would have been made possible. By the installation of loops and parallel lines many pumping stations could have been dispensed with, fewer lines of communication would have sufficed, and the necessity for construction of some lines might have been obviated entirely.

With the extension of the Mid-Continent field and an increase in production since 1915, pipe-line facilities have greatly increased. In part, this has resulted in looping and paralleling of existing lines without the construction of additional pumping stations, and to this extent the growth has made for greater economy and efficiency in operation. On the other hand, this development could no doubt have taken place more economically under unified control.

The above discussion applies primarily to trunk pipe lines. A similar waste through duplication, however, may be noted in gathering lines which serve local pools and wells by transporting the oil to trunk-line stations. It will be recalled that oil pools are developed in a haphazard, planless fashion. The unit of exploitation is the property tract. Adjacent plots are quite frequently operated by competing concerns; for example, by December 21, 1919, a compact area of the Ranger field embracing roughly twenty-five square miles had been divided for exploitation purposes into two hundred property tracts ranging in size from one to one thousand acres, operated by seventy-three competing companies and served by six major pipe lines. The holdings of the larger companies are scattered in a hodge-podge fashion throughout the whole area. The division of a geologic unit or a series of such units for exploitation purposes into small competing tracts served by competing pipe-

line companies, not only means tremendous waste in production as previously explained, but it prevents the construction of a scientifically planned pipe-line system designed to gather and transport the crude petroleum at a minimum of expense. Each of the six major pipe lines served this entire section of the Ranger field at the close of 1919. The properties from which each gathered oil were scattered throughout the entire pool. Figure XIII, p. 151, shows a small area, approximately 650 acres in extent, including all or a part of twenty property tracts from which five different pipe-line companies gathered petroleum. From such lack of method there results an entanglement of competing pipe lines rather than a unified system of petroleum transportation.

In order that the gathering service of any company may be responsive to the needs of the field, frequent extensions of pipe to new producing properties and withdrawals from exhausted properties must be made. By each separate company, there is, therefore, a more or less constant pipe-shifting process going on in the gathering system. The lack of coördination and unification greatly increases the magnitude of this shifting process, thereby greatly increasing the maintenance charge for all companies. In particular, the items chargeable to changing construction and repairs and renewals are magnified. In this regard it is of interest to note that an average of approximately 12 per cent of the total operating expenses for the gathering system of three of the major companies in 1912 and 1913 was credited to these two items.

Oil production as described in previous chapters is a speculative enterprise, the pecuniary outcome of which is hazardous and uncertain. Oil wells show a high initial production, followed by a certain and sometimes rapid decline. Oil pools become exhausted over a period of years and centers of production shift. Pipe-line facilities are dependent upon oil-producing areas for their fluid cargo. These facts, coupled with the magnitude and fixed nature

of investments in pipe-line facilities and their frequent incomplete utilization and high costs, would suggest that pipe-line transportation is also a hazardous undertaking. As our pipe-line systems have developed there is an element of truth in the suggestion, and yet it should be subject to rigorous qualifications, particularly in its application to trunk pipe lines. The chief function of such lines is to transport crude oil from production areas to refining centers. Refining centers are in the main population centers and have shown little tendency to shift. While oil wells and oil pools come and go, the more important oil fields have had a life extending over a great many years. For more than fifty years the Appalachian field produced more than 50 per cent of the total output of the United States and even to-day the annual output from this general region is in excess of what it was thirty-five years ago. Pools have declined and become exhausted but through new discoveries and extensions the proven territory has widened and the output increased. Consequently, trunk lines by extensions and additions may be made to do service over an ever-widening territory for many years.

The Mid-Continent field was not an important factor in the crude supply until the present century. By 1905 this region was yielding about 9 per cent of the total production for this country. By 1921 the percentage of production had increased to approximately 77 per cent, the annual output totaling 343,928,000 barrels. Thus, by an extension of proven areas and an increase in total productivity the hazard of the pipe-line business had greatly decreased. The oil-producing territory in Kansas and Oklahoma alone to-day covers an area of more than two hundred miles north and south and one hundred miles from east to west, and includes several hundred well-defined pools. A network of gathering lines serving the various pools has been laid through the areas connecting the main trunk lines with the producing pools. The pools have not all been equally productive. Some have reached the point of exhaustion very

quickly, while in others production has held up for many years. But with a widening of proven area and an increase in aggregate production the business of trunk-pipe-line transportation has increased in security. Discovery of new pools and extensions of old ones have practically assured the continuity of large-scale production and given thereby comparative security to the fiscal investment in transportation lines, stations, and storage tanks. On the whole, the development of large interstate pipe-line systems has followed the rapid development of crude-oil production rather than anticipated it, with a general tendency to lag somewhat behind, thereby giving added financial security to the investment.

A consideration of the life of pipe lines serves to accentuate the impression that pipe-line investment is not unusually hazardous. Steel pipe laid in the ground is subject to slow deterioration. Its durability depends in large part upon the constituents of the soil in which it is laid and in some degree upon the pressure under which the line is operated. In certain soils chemical action brings quick deterioration and it is sometimes found necessary to lay pipe in cement for protection. Soil rusts are comparatively rare, however, and numerous lines in the Mid-Continent field have been in use for from ten to fifteen years without showing signs of weakness. The opinion has been expressed by oil transporters of the Eastern fields that a pipe line should last twenty-five years or more. Obviously, pumping stations and equipment are also liable to depreciation and obsolescence. These factors coupled with the comparatively long life of oil fields would seem to permit of a gradual readjustment in equipment and facilities from time to time to meet the needs and requirements of production yields.[1] In general, trunk pipe-line facilities in the

[1] If estimates of the total unmined oil resources of this country, presented in a previous chapter, are reliable, petroleum production may soon reach its maximum, in which case the discrepancy between transportation facilities and oil production may become of a positive nature and of increasing magnitude.

aggregate have been fairly well adjusted to the available volume of traffic, with a slight tendency to lag behind production yields.[1] Recurrently, however, competition has brought about marked maladjustment in the production and the available transportation facilities in particular pools and isolated fields. Once an oil pool has been discovered, production operations are rushed to completion, in a competitive effort to drain the underground reservoir. If a large initial production is secured, competing pipe-line companies in anticipation of further developments and prolonged production will hurriedly extend their lines into the new areas. But it is ofttimes impossible to estimate with any approach to accuracy the future productive performance of developing fields. By the time pipe-line facilities sufficient to handle the prophesied production have been extended to the territory, production may have reached its peak, and a rapid decline may have set in. The result of such oil-field performance is that pipe-line capacity to a particular pool is rarely suited to the available volume of traffic. The Ranger, Texas, field affords an excellent illustration in point. The spectacular and rapid fashion which characterized the development of the pool has already been recounted. The initial well was completed in the fall of 1917. A year later an extensive drilling programme was well under way. The completion of several wells with large initial production during the summer and fall of 1918 created a general belief among oil producers that Eastland County would develop into an oil field of tremendous proportions.[2] Encouraged by the large initial

[1] This statement does not contradict the foregoing discussion in regard to duplication. Duplication in general has not resulted in a large surplus of capacity, but rather, available capacity has been purchased at an unnecessarily high cost.

[2] The Texas and Pacific Coal and Oil Company completed its first well on the F. Brewer tract in June, 1918, with an initial production of 2000 barrels daily. The Humble Oil and Refining Company completed its first well on the J. W. Jones tract in August, 1918, with an initial production of 4000 barrels daily. The Texas and Pacific Coal and Oil Company completed a well on the J. E. Butler tract during September,

production of the first wells and by the extensive drilling programme in progress, the major pipe-line companies serving the Mid-Continent field made plans for the extension of their systems to the newly discovered Eastland County pool. As early as the summer of 1918 three companies had construction well under way and by the close of the year had made connections with the producing area. Meanwhile production operations had proceeded at an even more rapid pace and throughout the fall of the year development was retarded awaiting the completion of adequate storage and transportation facilities.[1] The producing areas had been greatly extended by the discovery of oil pools to the north in Stephens County and to the southeast at the junction of the Erath County, Comanche County, and Eastland County boundary lines. By the spring of 1919 the combined daily production of these pools had reached approximately 100,000 barrels,[2] while the capacity of available pipe-line facilities was approximately 53,000 barrels daily.[3] This tremendous excess of production over

1918, with an initial daily production of 3000 barrels, and before the close of the year, completed five additional wells on the F. Brewer tract with a combined daily flush production of almost 7000 barrels.

[1] *National Petroleum News*, November 20, 1918, p. 29.

[2] The average daily production for the week ending March 2, 1919, is given by the *Oil and Gas Journal*, as 97,095 barrels.

[3] Pipe-line capacity depends upon a number of variable factors chief among which are the diameter of the pipe, the distance between pumping stations, the power of the pumping plants, the hydraulic gradient between terminal and intermediate stations governed by the highest and lowest points on the line, and the physical characteristics of the petroleum transported. Unless otherwise stated, figures on the capacity of pipe lines serving the Ranger field which are presented herein were secured from the offices of the companies concerned. The above figure represents an average daily capacity of 14,000 barrels for the lines of the Sinclair Pipe Line Company, extending from Ranger, Texas, northward where it joined with the main line at Healdton, Oklahoma; an average daily capacity of 25,000 barrels for the line of the Texas Pipe Line Company, extending from Ranger, Texas, eastward to Fort Worth, Texas, where it connected with the Texas Company's main line extending from Electra, Texas, to the Gulf Coast; and an average daily capacity of 14,000 barrels for the line of the Prairie Pipe-Line Company, extending from Ranger, Texas, to Drumwright, Oklahoma,

pipe-line transportation facilities not only stimulated construction activities on lines not yet completed,[1] but it also led to an expansion in the construction programme to meet the anticipated needs of a rapidly developing area. By September, 1919, production had increased to almost 150,000 barrels daily [2] while the daily capacity of completed lines totaled approximately 119,000 barrels.[3] After September there was a steady decline in production until May 1, 1920, at which time the Stephens-Eastland County pools had a combined daily production of only 81,000 barrels. Notwithstanding this decline in daily output which began in the fall of 1919 pipe lines on which construction had already been started were carried to completion, and by May, 1920, the pipe lines transporting crude oil from this region if operated at maximum capacity would have afforded an outlet for approximately 200,000 barrels of oil daily.[4] The trunk pipe lines serving the Eastland-Stephens County territory after the completion of the construction programme are pictured on the accompanying map (Figure

where it joined with the Prairie's main line to the north. See *The National Petroleum News*, February 26, 1919.

[1] The Magnolia Petroleum Company completed a line with a maximum daily capacity of 20,000 barrels in April, 1919. This line extended from Ranger, Texas, to Corsicana, Texas, where it joined with the main trunk line from Electra, Texas, to the Gulf Coast.

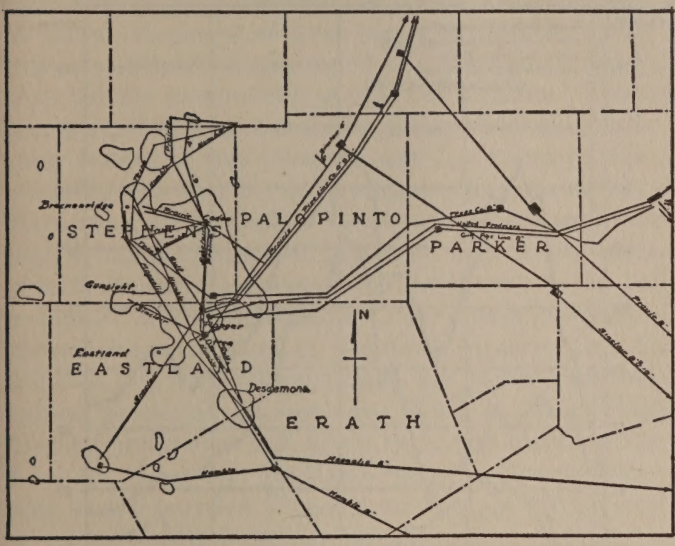
[2] The daily average production for the week ending August 29, 1919, is given by the *Oil and Gas Journal* as 149,105 barrels.

[3] The capacity of the Prairie's line had been increased to approximately 60,000 barrels, by the construction of additional pumping stations and by paralleling the existing 8-inch line with a 12-inch line. *National Petroleum News*, July 22, 1919.

[4] The maximum daily capacity of the above mentioned lines in the aggregate was rated at about 133,000 barrels. In addition to these lines three other lines had been completed. The Gulf Pipe Line Company had completed a line with a maximum daily capacity of 25,000 barrels, extending from Ranger, Texas, to Fort Worth where it connected with the Gulf Company's Fort Worth refinery; the United Producers Pipe Line Company had completed a line with a maximum daily capacity of 12,000 barrels, extending from Ranger, Texas, to Fort Worth; and the Humble Pipe Line Company had completed a line extending from Comyn to Webster, Texas, with a maximum daily capacity of 30,000 barrels.

XXVIII). It will be noted that all these lines converge in the vicinity of the Ranger pool, and with the exception of the Humble and Magnolia lines, which were constructed first to the Desdemona pool, they were all constructed directly to Ranger and intended as a source of outlet pri-

FIGURE XXVIII. MAP SHOWING THE TRUNK PIPE LINES SERVING THE EASTLAND-STEPHENS COUNTY OIL FIELDS

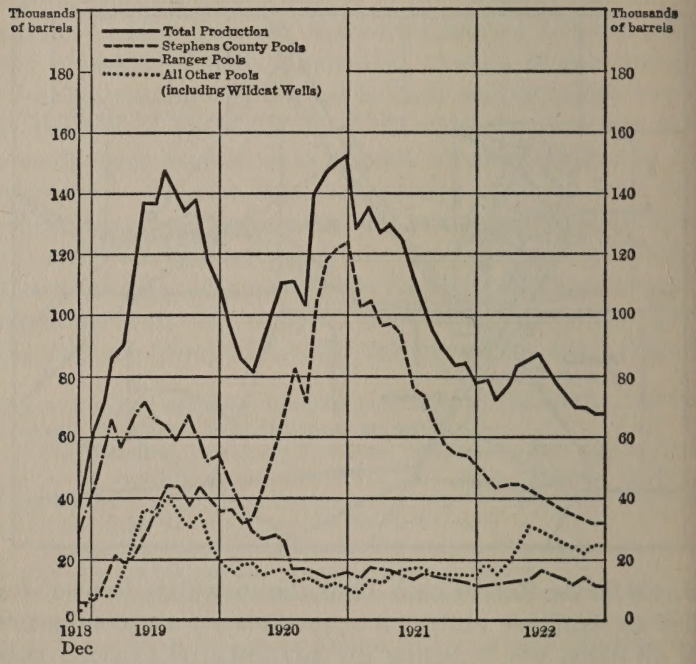


marily for the Ranger pool. Thus, the immediate Ranger area had an available outlet for approximately 150,000 barrels of oil daily, not including the 50,000-barrel capacity connecting first with the Desdemona pool. The Ranger field reached its maximum production about June 27, 1919, with a daily yield of about 73,400 barrels.[1] (See Figure XXIX.) Since that date the daily production of this pool has steadily declined until by the close of 1922 its daily production was only about 12,000 barrels. The pipe lines converging at Ranger, however, were made available in

[1] The *Oil and Gas Journal* gave the production for the Ranger field for the week ending June 27, 1919, as 73,460 barrels.

part for the production of the Desdemona pool to the southeast and for the Stephens County pools to the north by the construction of extensions connecting with the main trunk line. It will be recalled that the combined daily production of these various pools had reached approximately

FIGURE XXIX. PRODUCTION CURVES FOR THE EASTLAND-STEPHENS COUNTY OIL FIELDS, 1919–1922



150,000 barrels in September, 1919, and had thereafter steadily declined until it reached 81,000 barrels on May 1, 1920. After this date, due primarily to new developments in Stephens County, the combined production showed a steady increase until a new peak was attained with a daily output of approximately 152,500 barrels by January 1, 1921. The pools of Stephens County alone accounted for approximately 124,000 barrels of this amount. As stated above, the total maximum capacity of pipe lines available

for the transportation of petroleum from the general Eastland-Stephens County area was roughly 200,000 barrels. But while the capacity of the lines was considerably in excess of daily production, it was not apportioned to the various pools according to their output. The lines as originally constructed converged at or near Ranger. As production had increased in other pools most of the companies extended their lines to meet the needs of the developing areas. But in the development of local pools, production, under the urge of competition, proceeded at a much more rapid pace than did the construction of pipe-line facilities.[1] The result was a repetition of the earlier Ranger experience. In the early history of developments pipe-line capacity was considerably less than the daily output of petroleum, but with the passing of the peak of production, transportation companies found themselves burdened with heavy excess of pipe facilities.[2] In general, the production curve for the combined Eastland-Stephens County area has moved in consonance with that of Stephens County (See Figure XXIX), and since January, 1921, has shown a marked and rather persistent decline. By April 1, 1923, Stephens County production had fallen to 30,000 barrels while the total for the entire Eastland-Stephens County area was only 61,000 barrels.[3] Pipe-line capacity, it will be recalled, was approximately 200,000 barrels.

[1] Pipe-line companies in the face of the recent rapid decline of the wells in the Ranger pool were less energetic in their programme of construction, fearing that the large initial production of the new pools was only of a temporary character.

[2] The Breckenridge pool in Stephens County and the Desdemona pool in Eastland and Comanche counties afford an illustration at point. In both these territories, when production was at its height, there was an acute shortage of transportation and storage facilities. The situation became so acute in the fall of 1920 in the Breckenridge area that State interference with the drilling programme seemed imminent and was avoided only by the active coöperation on the part of the producers in the field and a rather precipitous decline in output once the peak had been attained. See *National Petroleum News*, October 20, November 3, and November 17, 1920.

[3] This figure includes the production in adjoining counties, as well

Such lack of coördination between pipe-line capacity and oil production occasions significant waste of a twofold character. In the early history of a field with production operations being conducted at a breakneck speed, wells are frequently completed before either adequate storage or transportation facilities are available. In the development of the Burkburnett field of Northern Texas and the Eastland-Stephens County field, considered above, so rapid were the development operations that it was necessary in frequent instances to utilize earthen storage of a temporary nature. There resulted enormous losses from evaporation of the more volatile petroleum constituents.[1] In the later history of the field with pipe-line capacity greatly in excess of oil to be transported, there results a partial utilization of expensive plant and equipment with a corresponding increase in costs of operation. Unfortunately, this latter situation cannot well be avoided. The nature of oil production renders imperative a certain lack of coördination in the transportation facilities and production of particular pools. Oil fields must necessarily reach a peak of production after which they show a steady decline. But a competitive construction programme of itself necessarily occasions a large element of waste through duplica-

as the production of wildcat wells scattered throughout the general Central Texas oil-producing area.

[1] Loss of petroleum by evaporation, while until recently disregarded entirely or accepted as inevitable, has been of very large proportions. A detailed field investigation conducted by the Bureau of Mines in 1919 indicated that, under current methods of handling oil in the Mid-Continent field, crude petroleum underwent a shrinkage of 6.2 per cent by volume in its entire journey from the mouth of the well to the refinery. The test, of course, involved normal methods of handling where adequate storage facilities were available. Where earthen storage is resorted to a much larger percentage is lost through evaporation and absorption by the earth's surface. The percentage of loss by evaporation as established by the Bureau of Mines' investigation when applied to the total volume of production in the Mid-Continent field in 1919, 196,000,000 barrels, indicated a total evaporation loss for that year alone of 12,152,000 barrels, with a value at 1919 prices of approximately $36,456,000. See J. H. Wiggin, *Evaporation Loss of Petroleum in the Mid-Continent Field*, Bulletin 200, Bureau of Mines, p. 86.

tion. Waste in this regard was especially patent in the construction of the pipe-line system serving the Eastland-Stephens County fields. Three lines, that of the Texas Pipe Line Company, that of the United Producers Company, and that of the Gulf Pipe Line Company, all serving the Ranger field, practically parallel each other throughout their entire length. Two other lines to the north, that of the Sinclair Pipe Line Company and that of the Prairie Pipe Line Company, parallel each other throughout a good portion of their extent. All these lines are comparatively small lines.[1] They were constructed and operated, however, as distinct units with separate equipment and management.[2] Had these five competing lines been replaced with a single or twofold system under a unified management, it would have been possible to secure a capacity equal to that actually attained at a much lower cost. With the element of competition eliminated, the construction of an adequate pipe-line system would have become a problem of engineering technique rather than a problem of business craft.

Thus, both the extraction of petroleum from its underground reservoir and its transportation to the refinery are fundamentally ill-adapted to the competitive system. A failure to recognize this fact has meant in the one case the waste of a large portion of a limited natural resource, and in the other, it has involved a waste of the community's capital in the utilization of that portion of the resource which has been saved.

[1] All are single lines 8 inches in diameter or less, save the Prairie line which consists throughout a portion of its length of parallel lines 8 inches and 12 inches in diameter.

[2] Before construction work had been started on the Magnolia or Gulf lines, it was suggested by the National Petroleum War Service Committee in the interests of conservation, that these two companies unite in the construction of a joint system. The suggestion seems not to have been followed, however. *National Petroleum News*, December 11, 1918, p. 42.

CHAPTER XII

THE UTILIZATION OF PETROLEUM: A PROBLEM OF CONSERVATION

THE problem of petroleum conservation is not solely a problem of the avoidance of waste in the recovery of the underground petroleum supply. This is perhaps the most important aspect of the problem; but secondary only to this, and of growing importance is the problem of conserving petroleum by an economical utilization of its products. Oil has been cheap and convenient to use. There has therefore been a distinct tendency to use it heedlessly without regard to the exhaustible nature of the resource or the relative permanent importance of its various products. In view of the wasting nature of our petroleum assets, and the apprehension which this has caused in recent years, it would seem desirable that we evaluate carefully the various economic uses of oil, giving proper attention to possible substitutes, in order that the more permanent and essential demands may be given due priority. An important problem, then, in connection with the conservation of petroleum is the extraction from the crude oil of the more socially essential products.[1] That the significance of this problem may

[1] We regard as essential those demands which if unfulfilled will necessitate serious readjustment in standards of living or in the technique of industry. The term is necessarily somewhat vague, but we believe that in this discussion it carries a sufficiently definite idea to justify its use. A failure in the world wheat and corn crops would no doubt bring with it dire distress and discomfort. A shortage of strawberries would result in less serious disturbances to our domestic and industrial life. Lubricants seem essential to our present industrial development and rapidly we are becoming a motorized Nation. For lubricating oils and gasoline there are as yet no satisfactory substitutes and failure to secure these two commodities in large quantities would work serious hardship upon individuals and the Nation. This situation seems likely to exist for some time to come. Fuel oil, on the other hand, while convenient and, with an abundant supply of petroleum, economical in use as com-

be fully understood it will be necessary to explain briefly the technique of petroleum refining and to examine the nature of the various petroleum constituents and the demand for them.[1]

The manufacture of crude petroleum is a distillation process. By the application of heat the successive components are vaporized and separately condensed. The resultant distillates may then be redistilled or chemically purified and made to yield the finished products of commerce. The refining of petroleum products is essentially a joint process. Under the application of heat the lighter petroleum components are given off and upon condensation yield what is commercially known as gasoline. At a somewhat higher temperature the less volatile fractions vaporize and upon condensation yield the commercial product kerosene. The undistilled residue may be disposed of as fuel or gas oil; but in the more complete type of refinery the distillation process is carried further, yielding fuel oil and a residue of lubricants.[2] There is no real difference in the character of these petroleum constituents aside from that of volatility. One merges into the other with no distinct line of demarcation between them.

pared with coal, is not a necessity in most of its uses inasmuch as coal which is found in greater abundance will accomplish virtually the same work. In discussing the social importance of these various petroleum products, we are concerned with the question: Which can we most readily dispense with? Were there an inexhaustible supply of petroleum the price factor might be relied upon to direct the distribution of the various products into the different channels of trade in amounts appropriate to their permanent economic importance. With temporary overproduction of a limited resource, the price factor tends to cause consumption of petroleum in a manner which does not take due account of the more permanent values contained in it.

[1] For a more complete analysis of this aspect of the problem, consult Pogue, *op. cit.*, from which much of the factual material presented in this chapter has been borrowed. For a more complete discussion of petroleum refining, see Bell, H. S., *American Petroleum Refining*, New York, 1923; Day, David I., Editor-in-Chief, *Handbook of the Petroleum Industry*, 1922.

[2] With oil of an asphalt base the lubricating content is also completely distilled off leaving a residue of asphalt.

The basic principles of refining have changed little since the advent of the industry, but under present practice refining is a highly technical matter varying both with the chemical nature of the oil and the local demand for the product. Ignoring all details we may note that there are three main types of refineries;[1] 'skimming' or 'topping' plants, complete refineries of the 'straight run' type, and complete refineries utilizing the 'cracking' process. 'Skimming' or 'topping' plants are so called because they 'skim' or 'top' the crude petroleum of only its lighter constituents, gasoline and kerosene. The remainder of the products are generally left as a residuum and are sold in this semi-crude state for fuel purposes.[2] The complete refinery of the 'straight run' type turns out all four of the main products, gasoline, kerosene, fuel oil, and lubricants, together with by-products. Under this process the crude oil is separated into its natural components with a minimum of chemical change. This process lacks the ability to produce more gasoline than the crude oil 'naturally' contains. Complete refineries employing the 'cracking' process likewise turn out a complete range of products, but this process yields a greater percentage of gasoline than is secured from crude oil under ordinary distillation. The 'cracking' process draws upon the heavier components for this surplus yield of gasoline. The heavier molecules are broken or 'cracked' into lighter molecules and hence just so much additional gasoline is obtained. The process is conducted at a high temperature under great pressure in so-called 'pressure' stills.

Let us turn from this brief consideration of refining methods to an analysis of the uses of petroleum and the extent to which modern civilization has become dependent upon its products. While petroleum enters into our commercial and domestic life at hundreds of different points,

[1] Gilbert, Chester G., and Pogue, J. E., *op. cit.*, pp. 45–46.

[2] Some skimming plants manufacture one or more of the heavier products as lubricants or asphalt and are sometimes called 'intermediate' plants.

the chief demand for its products is of a threefold nature. Oil is used primarily to produce light, to generate power, and to save power by the reduction of friction in the running of machinery. In response to these three needs its chief products are kerosene, gasoline and fuel oil, and lubricants.

While the basic principles underlying the refining of petroleum have changed little since the advent of the industry, the degree to which these principles have been applied has varied somewhat with the changing nature of the demands for its products. Table 8 shows in millions of barrels the annual production of crude oil, the amount of crude oil which has been run to the refinery stills in the specified years, absolute and relative amounts of the four most important products which the crude has yielded, and the percentage increase in the production of these various products over the base year 1899.

In the incipient stages of the industry and until the development of the internal combustion engine, kerosene, which was used primarily as an illuminant, was the most important commercial product. Whale-oil and tallow candles quickly gave way to this cheaper and more convenient illuminant. As the production of petroleum increased, the trade in kerosene widened until kerosene literally pushed its way into the uttermost parts of the earth. It very early became an important item in our export trade, first to European countries and later to the Orient. By the close of the century the demand for kerosene required 58 per cent of the total quantity of crude oil refined. But as the supply of raw material for the manufacture of kerosene continued to grow, the commercial development of gas and electricity began to narrow its domestic market. This threw still greater emphasis from a commercial point of view upon the importance of expanding the foreign outlet. Export requirements have continued to bulk large and in 1923 approximately 40 per cent of our annual kerosene production was used to meet the needs of foreign peoples. During the last two decades electricity

TABLE 8. ANNUAL PRODUCTION OF CRUDE OIL, CRUDE OIL RUN TO THE STILLS, AND PRODUCTION OF THE PRINCIPAL PETROLEUM PRODUCTS IN THOUSANDS OF BARRELS; PERCENTAGE RECOVERY OF THE FOUR PRINCIPAL PRODUCTS, FROM THE CRUDE RUN TO THE STILLS, 1899–1923

YEAR	CRUDE OIL PRODUCED IN UNITED STATES		CRUDE OIL RUN TO STILLS		GASOLINE			KEROSENE			LUBRICATING OIL			GAS AND FUEL OILS		
	Thousand Barrels	Index Numbers	Thousand Barrels	Index Numbers	Thousand Barrels	Percentage of Crude Oil Run to Stills	Index Numbers	Thousand Barrels	Percentage of Crude Oil Run to Stills	Index Numbers	Thousand Barrels	Percentage of Crude Oil Run to Stills	Index Numbers	Thousand Barrels	Percentage of Crude Oil Run to Stills	Index Numbers
1899	57,071	100	51,905	100	6,689	12.8	100	29,976	57.7	100	4,047	7.7	100	7,262	13.9	100
1904	117,081	205	66,905	129	6,929	10.3	104	32,310	48.2	108	7,500	11.2	185	8,571	12.8	118
1909	183,171	321	120,714	233	12,857	10.6	192	39,881	33.0	133	12,786	10.5	316	40,524	39.4	558
1914	265,763	466	191,429	369	35,714	18.6	534	46,071	24.0	154	12,310	6.4	304	88,905	46.4	1,224
1917	335,316	588	315,132	607	67,870	21.5	1,015	41,114	13.0	137	17,947	5.6	443	155,079	49.2	2,136
1918	355,928	624	326,025	628	85,007	26.0	1,271	43,461	13.3	145	20,035	6.1	495	174,319	53.4	2,400
1919	378,367	663	361,520	697	94,235	26.0	1,409	55,753	15.4	186	20,161	5.5	498	181,602	50.2	2,501
1920	442,929	776	433,915	836	116,251	26.7	1,738	55,240	12.7	184	24,922	5.7	616	210,987	48.6	2,905
1921	472,183	827	443,363	854	122,704	27.6	1,834	46,313	10.4	154	20,901	4.7	516	230,091	51.8	3,168
1922	557,531	977	500,706	965	147,672	29.4	2,208	54,913	10.9	183	23,304	4.6	576	254,910	50.9	3,510
1923	732,407	1,283	581,238	1,120	179,903	30.9	2,691	55,927	9.4	186	26,128	4.4	646	287,481	49.4	3,959

and artificial gas have further relieved the oil industry of the burden of its responsibility of lighting the life and lengthening the days of the citizens of this country and the peoples of the world. The electric light has completely superseded the oil lamp for lighting purposes in our cities, and more and more, too, the country districts are being supplied through high-tension lines and farm electric units with an adequate supply of this more satisfactory lighting fluid. By 1923 the relative importance of kerosene had so declined that it consumed by volume only 9.4 per cent of the total crude oil run to the stills.

The demand for lubricants from a quantitative standpoint has always been subordinate to that for kerosene, but its significance as a factor in social progress has perhaps been greater. With the increased use of machinery, incidental to the growth of large-scale production and the expansion of industry, and with the rapid extension of our railway system, which characterized the closing quarter of the nineteenth century, the demand for lubricating oils assumed greater importance and the complete type of refinery came into more general vogue. Had it not been for rapid progress in this line the whole stupendous development of industrial civilization since the second half of the nineteenth century might have been greatly curtailed. This development has been largely in terms of machinery, and machinery without lubricants is impossible. The important rôle which lubricants play in our modern system of production is little appreciated or too frequently taken for granted. In the words of Dr. George Otis Smith, in an address before a recent meeting of the American Iron and Steel Institute:[1]

> In our attention to the generation of power to meet the needs of industry and transportation, we give too little thought to the unique function of oil — that of saving power. Machinery without lubrication is unthinkable, adequate lubrication saves energy and makes it available for use as well as adds to the life of the machine.

[1] Quoted by Pasvolsky, Leo, in 'Civilization and Oil,' *The Atlantic Monthly*, vol. 131, p. 269.

Prior to the discovery and development of oil as a source of lubricants, the chief source of supply was derived from various kinds of animal and vegetable fats, as well as such solid substances as graphite. These substances are still used to a slight extent, but the rôle which they now play in industry is almost negligible in comparison with that played by the mineral-oil lubricants. Already there seems to be no substitute for the latter in the quantity demanded by the needs of modern machinery,[1] and the demand for them may be expected to show perhaps a slow but a steady increase with the passing of time.

But of greater importance from a commercial standpoint in recent years than either kerosene or lubricants is the demand for gasoline. The rapidity with which the production of gasoline has increased is set forth in the foregoing table. It will be noted that production increased from 6,689,000 barrels in 1899 to 179,903,000 barrels in 1923, an increase of 2691 per cent. Likewise, there has been an upward trend in the proportion of crude oil run to the stills which has been recovered as gasoline. Since the advent of the motor car, kerosene, which was formerly the most important petroleum product, has been relegated to a subordinate position, and gasoline has for some time been the stress product.[2] The automobile has furnished the impetus for this demand. The growing significance

[1] The suggestion is ventured by Mr. Pasvolsky that to supply vegetable fats in the quantity necessary to meet all our demands for lubrication would require an acreage which would constitute a serious inroad upon the world's food supply. See Pasvolsky, *op. cit.*

[2] It will be noted that from the standpoints both of the absolute amounts produced and the percentages which these amounts bear to the total crude run to the still, since 1899 gas and fuel oil have been more important than gasoline. This results from two causes: first, because of the fact that a large proportion of the total production has been low-gravity oil which, under current methods of refining, yields a relatively small amount of the more volatile petroleum constituents; and second, because of the fact that the total supply of high-gravity oils and low-gravity oils together has been so plentiful as to encourage incomplete refining. Fuel oil, in an economic sense, is a residue after the demand for other products has been satisfied.

of the automobile in this regard is evidenced by the fact that while in 1911 there were in round numbers only 640,000 motor vehicles registered in the entire United States, by 1923 this number had increased to more than fifteen million.[1] In twelve years there had been an increase of approximately 2358 per cent. Assuming that the percentage of gasoline recovery from petroleum and the consumption requirements per car were the same in 1923 as in 1911, petroleum must have shown a similar increase to have supplied the demand for gasoline. As a matter of fact petroleum production showed an increase of only 232 per cent during this period. In 1911 there were available 344 barrels of crude oil as a potential source of gasoline for every motor car in the United States; in 1912, the per-car availability had decreased to 236 barrels; in 1913, to 193 barrels; in 1914, to 155 barrels; in 1915, to 115 barrels; in 1916, to 86 barrels; in 1917, to 66 barrels; in 1918, to 58 barrels; in 1919, to 50 barrels; in 1920, to 48 barrels; in 1921, to 45 barrels; in 1922 it remained constant at 45 barrels; and in 1923 there was an increase to 48.5 barrels. Save only for the last period the number of gasoline-driven machines in use has increased consistently faster than the production of the crude commodity from which gasoline is derived. Nor is there apt to be a reversal of this tendency in the immediate future. The Research Department of the Franklin Automobile Company has made calculations as to the probable number of motor vehicles which will be required by automotive transportation in the near future. This calculation was based on the trend of population increase and the assumption that the maximum ratio of vehicles to population as found at the time the calculation was made in the most prosperous sections will become characteristic of the entire country. According to this estimate, 1940 will see slightly more than thirty million motor vehicles in use in this country alone.[2] It is interesting to note

[1] National Automobile Chamber of Commerce, *Facts and Figures of the Automobile Industry*, 1924.

[2] *Automotive Industries*, April 28, 1921.

that the demand for automobiles has exceeded somewhat the anticipations of the Franklin Company. According to their estimate, there would have been slightly over 11,000,000 motor cars registered in 1922, approximately 12,500,000 in 1923, and slightly under 14,000,000 in 1924. Actual domestic registrations for 1922 totaled 12,238,375; for 1923, 15,092,177; while preliminary figures for 1924 indicate a total registration of approximately 17,000,000. On the other hand, the oil industry seems to have been doing somewhat better than has been anticipated generally. Despite frequent forecasts of impending decline in output, 1923 showed a total domestic production in round numbers of 732,000,000 barrels, an increase of 182,000,000 barrels over 1922. It should be noted, however, that, according to preliminary figures, 1924 witnessed a decline in output to 707,265,000 barrels with a per-car availability of 41.5 barrels. In view of the fundamental nature of oil production and the estimated unmined reserve, domestic production can scarcely be expected to expand at the rate which it has done within the past few years; on the contrary, commercial output seems not unlikely to undergo a permanent decline within the not far distant future. With automobile transportation on the increase, this augurs a further decline in per-car availability of crude oil.

Why, with a persistently declining per-car availability of crude oil, has there not been a shortage of gasoline? Gasoline is secured to-day from three principal sources: gasoline, the product obtained in the ordinary distillation of crude petroleum either in skimming plants or straight-run refineries; cracked gasoline, secured, as previously explained, by a more complete refinery process; and natural-gas gasoline, obtained by absorption or compression processes from natural gas. Each of these sources has contributed somewhat to this increase in the supply of gasoline. Greater attention has been given to the cracking process, and, while thus far relatively only a small portion of the total gasoline supply has come from this source, it no

doubt offers a future means for increasing the percentage of gasoline recovered from available crude. Likewise, within recent years increased attention has been given to the production of gasoline from natural gas. Natural-gas gasoline is a very volatile liquid consisting only of the lighter ends and must always be blended with heavier components to form the commercial product. As previously explained, throughout most of the history of the industry a large part of the potential supply of this highly volatile and very valuable fluid has been allowed to disappear into the atmosphere in a gaseous state — a waste incidental to competition in oil production. Nevertheless, production of gasoline from this source increased from 24.1 million gallons in 1913 to 816.2 million gallons in 1923 and at this latter date approximately 10 per cent of the total gasoline supply was secured from this source. But in view of the probable future decline in domestic production of gas, this source cannot be expected long to continue to yield an increasing proportion of our gasoline supply.

By far the greater portion of our gasoline supply thus far has come from the ordinary straight-run or skimming refinery process. How, then, has the increase in gasoline production so greatly outrun the increase in production of crude petroleum? It will be recalled that since 1899 kerosene has drawn less heavily upon the crude product run to the refinery stills. Kerosene and gasoline are both distillates in the refining of crude oil. A fact previously mentioned should also be recalled at this point: there is no distinct line of demarcation between gasoline and the less volatile petroleum products. As Mr. Pogue has expressed it: 'Gasoline is not a single chemical product possessing definite properties, but is a series of related compounds running from hydrocarbons with small, light molecules to hydrocarbons of larger and heavier molecular character. Gasoline, therefore, is a chain of compounds ranging from light, highly volatile components through graded inter-

mediates to relatively heavy, less volatile end-products.'[1] The character of the components at the heavy end, or the extent to which the distillation process is carried, has been determined in large part by the force of temporary economic factors. With the demand for kerosene growing relatively less important, the heavier components have been utilized as a source of motive power. Throughout the decade from 1910 to 1920 the end-points of gasoline have moved consistently upward.[2] During this period the end-points climbed from the neighborhood of 300° F. to over 450°.[3] This accounts in the main for the increased percentage of gasoline recovered from crude run to the stills, for as we raise the end-point we increase the volume of the distillate. But obviously the process cannot be carried on indefinitely. Present auto-motors are not suited to a gasoline with a much higher end-point than that now distilled. A rising end-point has meant a greater volume of gasoline, but it has also meant a poorer grade of gasoline.

By an increased recovery of natural-gas gasoline, a further application of the cracking process, and a rising end-point, the crude supply has been enabled to meet the demands placed upon it. With the end-point of 1914, the 1920 supply of gasoline would have fallen some 10 per cent below the amount needed.

[1] Pogue, *op. cit.*, p. 112.

[2] The end-point marks the Fahrenheit temperature at which successive tenths of the fluid distil off. A rising end-point indicates utilization of heavier components. The extent to which the process can be carried is limited by the nature of the engine. 'The initial point indicates the readily vaporized components that determine the ease with which the engine may be started, while the end-point measures the extent to which heavy components are present that tend to pass through the engine incompletely burned.' *Idem.*

[3] The end-point varies with different grades of gasoline and likewise it tends to vary with different seasons of the year. Thus, in the summer months, with increasing demand, gasoline tends to have a higher end-point, and with the falling off of demand in the winter time the end-point tends to fall; that is, refinery practice is adjusted to the seasonal demand for gasoline. With the recent overproduction of crude, gasoline has shown a tendency to encroach less upon the heavier petroleum constituents, and the average end-point for ten districts had declined to 436° by July, 1923.

In the increase of petroleum production gasoline has been the stress factor. Throughout the last decade the causal sequence has run: a rapid expansion in the automotive industry; a corresponding increase in the demand for gasoline; an increase in the production of petroleum. The influence has been reciprocal, however, the increase in gasoline production making possible the rapid development of the automobile. But in recent years, among all the products of petroleum, the demand for gasoline has represented the strongest urge to petroleum production. In response to this urge petroleum production has proceeded at a tremendous rate with the result that petroleum has been brought on to the market so rapidly that it has been profitable to utilize it in a socially uneconomic fashion. Gasoline, which has furnished the impetus to this expansion in production, has not reaped its full quantitative reward. It has been foiled in an economic sense by the competitive price system. How and to what extent? Under a system of competitive business enterprise, the division and disposal of petroleum and its products have been determined by the price factor. The available supply of the various petroleum constituents has been a function of price. In the long run, under normal conditions this of itself would lead to an economical utilization of petroleum products. In response to a growing demand for a particular product, as for example gasoline, we should expect an increase in the price of this product and a corresponding adjustment of refinery practice to meet this shift in demand. This in part has taken place in the shift in emphasis from kerosene to gasoline. Economic pressure has thus led to more economical refining practices. But the pressure has not been sufficiently great to effect a perfect adjustment between demand and available refining technology. It will be observed that the increase in the production of fuel oil and gas oil has been even more pronounced than the increase in the production of gasoline. Thus, the production of fuel and gas oils from 1899 to 1923 showed an increase of more than 3959 per cent,

while gasoline production increased only 2691 per cent. While this increasing volume of fuel oil has been derived solely from crude petroleum, it has drawn upon the latter in three ways. Portions of the heavier crude oils, ill-adapted to a ready high-percentage yield of gasoline, have been used as such for fuel purposes; refineries of the more complete type have furnished a considerable volume of heavier distillates in the production of lubricants which have contributed to the available supply; and the residuum derived from skimming and topping plants after the lighter components, gasoline and kerosene, have been removed, has made up the balance.

From 1918 to 1923 an annual average of approximately seventy-five million barrels, composed largely of the heavier grades of crude oil, has been used directly for fuel purposes. While it has been profitable at prevailing prices so to dispose of crude oil, it has been uneconomical, since its consumption as such has involved the waste of the more essential products, gasoline and lubricants. While distillates from the complete refineries have made up the smallest portion of our fuel oil supply, in 1919 approximately thirty million barrels were secured from this source. This represents about 30 per cent of the crude oil consumed in such refineries.[1] These distillates can be subjected to further refining under the cracking process whereby the heavier molecules are broken down into the lighter components with a yield of approximately 50 per cent of gasoline.[2] The residuum derived from the skimming and topping plants after the lighter components have been removed comprises the chief source of our fuel-oil supply. Such plants usually accompany flush production in newly developed oil fields. They

[1] The yield of fuel oil varies with the grade of the crude and the completeness of the refining process. It runs from about 12 per cent in the case of Mid-Continent crude refined by the steam distillation process to 44 per cent with Gulf Coast crude under the same process. See Pogue, *op. cit.*, p. 78.

[2] The amount of gasoline secured will depend upon the grade of the distillate and the completeness of the refining process.

can be built with relatively little capital and often prove exceedingly profitable when crude oil is abundant and cheap. Under the influence of competition they have sprung up very rapidly in all newly opened territory and are a characteristic feature of oil-field development. They may be constructed by the larger companies to take care of temporary surplus production and to supply local demands; or they may be built by small stock companies whose chief interest is a speculative one. In some instances such refineries have been completed without ever subsequently refining any oil. When operating as skimming plants they recover only the easy-to-get values, the oil being topped or skimmed of the more volatile fractions and the residuum being consumed as fuel largely for steam-raising purposes. The consumption of this residuum as fuel oil involves a loss of a considerable portion of gasoline together with a quantity of lubricants. Refining equipment and technology are available to recover these lost products. That they have not been applied more generally is due largely to the fact that production has proceeded at such a rapid pace that it has not been sufficiently profitable to carry the oil through the more complete refining process. It will be noted that since the opening of the twentieth century fuel oil has drawn more heavily upon the crude run to the stills; the percentage of total crude oil run to the stills which was reclaimed as gas or fuel oil has increased from 15 per cent in 1899 to 50 per cent in 1922. As previously stated, fuel oil, in an economic sense, is the residue after the demands for other petroleum products have been satisfied. That the relative importance of this residue has been on the increase is to be accounted for in large part by the rapid rate with which the production of oil has expanded.[1] So rapid has

[1] It is to be accounted for in part by the relatively great increase in the output of oil of a low gravity sort and in part by the fact that some fuel oil may have been counted twice. Refineries which report to the Bureau of Mines use no uniform system of accounting. Hence it is difficult to determine the real significance of figures reported. Some refineries report their skimming operations as distinct from their crack-

been the increase in the rate of crude production that it has been unnecessary and unprofitable to extract from the fuel oil its potential volume of gasoline and lubricants. Our gasoline and lubricant supply has been secured by the utilization of only a portion of these constituents which the crude oil contained. The result has been a growing volume of fuel oil which has found its way into the market by the development of new demands. Unregulated production, carried on under highly competitive conditions, has prevented an adjustment between the demand for the more volatile petroleum constituents and the application of available refining technology in their recovery. Confronted with a large unutilized surplus of crude-oil constituents of the more socially valuable sort, we have disposed of this surplus in an expedient but perhaps improvident fashion — by burning it.

Thus, industry has witnessed a tendency to substitute fuel oil for coal in the generation of heat and power. The Pacific Coast region, in the absence of a convenient coal supply, has built its entire industrial structure upon fuel oil as a base. While the Eastern sections of the country are much less dependent upon fuel oil, its extension in these sections has been very rapid in recent years. To-day numerous railways utilize fuel oil as a source of motive power throughout all or a portion of their mileage. From 1909 to 1921 fuel-oil consumption by locomotives increased from 19,900,000 barrels to 33,900,000 barrels. In 1918 more than 35,000 miles of line were operated chiefly by fuel oil, an increase of approximately 100 per cent over 1909. The increase in the use of oil in marine transportation has been even more rapid. The shift from coal to oil in this field is being accomplished in two directions: by the conversion of coal burners into oil burners, and through the construction

ing operations, in which case their unfinished oils re-run and gas and fuel oils items may be too large, i.e., they may duplicate in certain indeterminate quantities. If so, the percentages of fuel and gas oils appear larger than they actually are.

of motor vessels.[1] The rapidity with which this movement has progressed is little short of spectacular. New construction in shipping, occasioned by the submarine ravage during the war, has served to accentuate the change. In June, 1914, of the total world's tonnage of merchant shipping only 3 per cent was fitted to use oil. By 1924 the proportion had increased to approximately 30 per cent. On June 30, 1924, of the gross tonnage of shipping under the British flag only 23 per cent was on an oil-burning basis, while 73 per cent of the tonnage under the American flag was fitted to burn oil. The United States Shipping Board is definitely committed to an oil-burning policy. Of the tonnage produced and under construction by this organization up to November, 1920, 49.9 per cent was constructed for the use of fuel oil exclusively, and 27.3 per cent was designed to use either coal or oil. By 1924, 85 per cent of the tonnage under the control of this organization was on an oil-burning basis.[2] Liquid fuel has such an advantage over coal in facilitating bunkering, increasing the radius of steaming, and conserving labor in firing that, as measures of national defense, all the navies of the world have been put largely on an oil-burning basis.[3] Nor has the use of petroleum for fuel purposes been confined entirely to fields of transportation. About 86,000,000 barrels were consumed for purely industrial purposes in 1918.

[1] In the former case the oil is used as a substitute for coal in generating steam, and in the latter case the Diesel or semi-Diesel type of internal combustion engine utilizes the oil directly. Direct utilization in the Diesel engine marks a distinct economic advance over the indirect utilization as fuel.

[2] Data from United States Shipping Board.

[3] Admiral Lord Fisher, of the British Navy, expresses the naval importance of fuel oil as follows:

'The use of fuel oil increases the strength of the British Navy 33 per cent because it can re-fuel at sea off the enemy's harbours. Coal necessitates about one third of the Fleet being absent re-fuelling at a base (in case of war with Germany) some three or four hundred miles off!

'With two similar Dreadnoughts oil gives three knots more speed — that is, if ships are designed to burn oil only instead of oil and coal — and speed is everything.

The increase of production of fuel oil from 7,262,000 barrels in 1899 to 287,481,000 barrels in 1923 is roughly indicative of the increasing importance which it has assumed in modern industrial and commercial activities. It should be emphasized, however, that while the rôle which fuel oil has played has been of growing importance, its widespread consumption for industrial and domestic heating purposes from a social viewpoint may prove to be an economic waste. Petroleum is a wasting asset. The time has long passed when the underground supply might be regarded as inexhaustible. While the world resource has been little exploited, our domestic reserve has experienced a tremendous shrinkage and there seems little doubt that this country is soon to become more and more dependent upon foreign sources of supply. Set off against this largely untouched but also undiscovered world reserve, the magnitude of which is not readily or accurately ascertainable, there is an incipient world demand which is only beginning to make itself felt. For certain petroleum products there are available no adequate satisfactory substitutes. Of these, lubricants are perhaps fundamentally the most essential for they support modern industrialism and their use cannot be dispensed with. But neither is there available an adequate substitute for gasoline, and in the immediate future this product seems likely to furnish the greatest urge to petroleum-production activities. Oil as a fuel substitute for coal is not a modern necessity.[1] It performs the same function which coal performs, and while it does so in a somewhat more satisfactory manner, the advantages gained

'Oil for steam-raising (i.e., burning under boilers) reduces the present engine and boiler-room personnel some 25 per cent, and for Internal Combustion Engines would perhaps reduce the personnel over 60 per cent.

'It is criminal folly to allow another pound of coal on board a fighting ship.'

Quoted by Davenport, E. H., and Cooke, Sidney Russell, in *The Oil Trusts and Anglo-American Relations* (New York, 1924), p. 5.

[1] Its use on naval vessels seems to have become a military measure necessary for efficiency.

may prove to be more than offset by the permanent losses involved. The coal deposits of this country and the world are abundant and well distributed. The coal resources of this country alone are adequate to meet the needs of perhaps a hundred generations of Americans. So that the fuel-oil problem, while it may in the future cause much temporary inconvenience and expense when a transition to coal may become necessary, is not a serious one.

The marked increase in the production of fuel oil, and hence in its consumption, has resulted in part from the fact that crude petroleum, under the highly competitive methods which have characterized its production, has been produced at a more rapid rate than would have been necessary to meet the more important demands placed upon it had full utilization been made of available refining technology. Uncontrolled production has meant temporary and recurring overproduction. Overproduction has meant cheap crude oil, and cheap crude oil has encouraged wasteful methods of refining and has placed pressure upon the utilization of oil for fuel purposes. During periods of temporary overproduction the oil industry, confronted with declining profits, has projected and executed effective campaigns in favor of a more general use of fuel oil for industrial and heating purposes. Thus when the war-stimulated output of fuel oil during 1919 found no adequate outlet and prices fell sharply, such a campaign was instituted, with the result that the price of fuel oil recovered promptly and by May, 1920, had reached a new peak fully 50 per cent higher than its war attainments of 1918.[1] Again in 1923 the country found itself flooded with petroleum and its products. The market had about reached the saturation point. In an endeavor to avoid a recurrence of this situation, the American Petroleum Institute appointed two

[1] The coal shortage due to the strikes in the bituminous fields in the late fall of 1919, was a strong contributing factor. To the break in price, incidental to the depression of 1920, fuel oil responded more quickly than any other petroleum product.

important committees, one to consider changes in our method of producing oil so that it would not be forced on the market beyond the ability of the market to absorb it at a profit, and the other to study the matter of utilization of petroleum products, i.e., to study means of bringing about a wider use of petroleum products. Mr. Henry L. Doherty, one of the members of the committee on utilization, in an address before a recent annual meeting of the American Petroleum Institute, urged the necessity for coöperation in this regard and suggested the desirability of spending not less than $10,000,000 in an advertising campaign. Mr. Doherty, while deprecating the devastation of our oil resources, expresses a typical business man's viewpoint as follows: [1]

> If oil for railroad use is worth half again as much as for use in the stationary power plant, then it is up to us to sell all the oil we can for railroad use.
>
> If oil is worth still more for ship propulsion than for railroad use, then we should endeavor to sell all the oil we can for ship propulsion.
>
> If it is worth still more for household heating than for ship propulsion, then we should endeavor to sell as much as we can for house-heating purposes.

While a campaign of the sort advocated by Mr. Doherty may help greatly in the solution of the business man's 'oil problem,' it only serves to complicate further the problem of oil for society. It not only directs immediately available petroleum supplies into a socially uneconomic channel but by creating new demands upon the industry it leads to a more rapid exploitation of our limited underground supply.

It has been suggested that the factor of price may be expected to check and eventually to eliminate such wasteful methods in the utilization of petroleum. Thus Mr. Pogue pictures the refining practice as developing through evolutionary stages: [2]

[1] Doherty, H. L., 'The Utilization of Petroleum Products,' *Bulletin, American Petroleum Institute*, December 31, 1923, p. 7.

[2] Pogue, *op. cit.*, p. 83.

At the outset of new developments, with cheap and abundant crude petroleum, skimming and topping plants develop according to the type of crude; then, with advancing conditions, these incomplete plants either fall or else change into intermediate refineries that effect a fuller extraction of values; later, with increasing stress, the growth is in the direction of complete refineries, in which fuller advantage is taken of the potentialities present in crude oil, and finally pressure stills are installed to carry the extraction of values still further by converting a low-value product into one of greater worth. While this evolutionary trend is not entirely sharply defined, and local complications are present, it is practically certain that ultimately the complete plant with cracking installations will quantitatively dominate the situation, just as this type of plant now leads in economic and financial strength.

There is, no doubt, much truth in this prognostication, and yet the fact remains that plants of the less complete sort make up the bulk of refining capacity of this country to-day. Also it is fairly certain that so long as production development repeats its antics of the past, with local and temporary overproduction, much of our petroleum supply will be wasted through incomplete and partial utilization.

Nor is it intended to deprecate the facts unnecessarily. They seem to follow naturally the development of petroleum under the influence of the price urge and the profit motive. The competitive system encourages and in some instances occasions such wasteful practices. It may well be that the force of the same influence may sooner or later act as a sort of brake to slow down the practice it has started. But such a braking process may mean uncomfortably high gasoline prices, and a partial readjustment in industry by a shift from fuel oil to coal.

Refinery statistics from the Bureau of Mines indicate that on January 1, 1921, 34.2 per cent of the refinery capacity of this country was of the simple skimming or topping plant variety. An additional 27.4 per cent was of the skimming-plant variety, but turned out one or more of the heavier components such as lubricating oil, asphalt or coke. Three per cent was unclassified, and only 38.4 per cent constituted complete plants turning out the whole range of petroleum

products. Of these last the percentage utilizing the cracking process is not shown, but it is a safe assumption that the greater number from a capacity standpoint did not employ this method. In 1918 the output of cracked gasoline in this country was approximately 360,000,000 gallons, or about one tenth of the country's total gasoline production. Most of this gasoline was made by the Burton process controlled by the Standard Oil Company of Indiana, but in some instances leased to certain other companies.[1] Oklahoma in 1919, with 107 refineries with a total capacity in excess of 200,000 barrels daily, had only fifteen plants utilizing the cracking process, with a total daily capacity of 34,900 barrels.[2] It may be contended that the cracking process is a relatively new technological advance and that with increasing demand for gasoline it will come into more general practice. And such seems to be the case; but thus far its progress has been retarded, because a rising end-point and an increasing petroleum production have been able to take care of the situation. If under the stress of competitive methods in oil production, the future witnesses a recurrence of the performances of the past with temporary and recurring overproduction, we may expect a further retardation in the shift to improved and more complete refining methods. Moreover, if the total world supply which may prove abundant for many years to come, should be recovered with the same rapidity which has characterized American production, incomplete refining methods may continue for some time, and when the stress of economic factors will have made itself entirely effective, it may be that the situation will have passed beyond the stage of remedy.[3]

[1] Pogue, *op. cit.*, p. 111.

[2] *Oil and Gas Journal Supplement*, May, 1919, p. 55.

[3] Due to the lack of uniformity in accounting methods used by refineries in their reports to the Bureau of Mines, and to the incomplete nature of these reports as at present available, it is impossible to determine accurately the growth which the cracking process has experienced. The Bureau of Mines has been collecting for some time

Before leaving this phase of the discussion, it is worth noting that economic forces which might have tended to hasten and widen the use of cracking have themselves been retarded by artificial obstruction. Our existing patent laws and the uncertain status of patents covering the cracking process are not conducive to general adoption of this more advanced refining technique. The first patent covering the process was issued to Dr. W. M. Burton, of the Standard Oil Company of Indiana in January, 1913, and assigned by Dr. Burton to that Company. By the close of 1922 the Standard had installed in its own refineries 295 pressure stills. During the same period the Company had issued licenses on a royalty or profit-sharing basis to eighteen refining companies, most of which belong to the Standard group.[1] The licenses quite generally contain the provision that gasoline produced by the patented process shall not be sold in territory covered by the marketing organization of the Standard of Indiana. The leasing company further reserves the right to buy back at an agreed price a certain proportion of the gasoline thus produced. Such restrictions do not make for the widest use of the process. Moreover, there are other factors which serve to prevent a rapid adoption of the cracking process. Since 1913 other patents have been issued covering the cracking of petroleum.[2] All of these involve the same basic principle — the breaking-down of the heavier petroleum molecules under heat and pressure into lighter molecules. The difference between the several methods lies in the nature and operation of the apparatus employed. Some of the patents have been of a broad nature — broader than the scope of the specifications,

additional material which may throw new light on the matter and a report is to be issued about July, 1925. Whatever this report may reveal as to progress made, it seems reasonably clear that progress has been retarded because of the influences analyzed above.

[1] *Hearings, op. cit.*, testimony of R. W. Stewart, president of the Standard of Indiana, p. 807.

[2] For a comprehensive list of such patents, see *Handbook of the Petroleum Industry, op. cit.*, vol. II, pp. 440–44.

apparently. The result has been that to-day several infringement suits are pending, and until the matter has been cleared up, any refinery that puts in a cracking process may simply be buying a lawsuit. Commenting upon this situation, the Senate Committee on Manufactures has the following to say:[1]

> The Standards of New Jersey and Indiana control what they claim to be basic patents. . . . Both of these companies are active in warning all the independents against the use of cracking processes, claiming, in some cases at least apparently without justification, that the cracking processes which independents were seeking to use were in violation of Standard patents, and thus for years, through threats and institution of suits, the industry generally has been deprived of processes by which the production of gasoline could be doubled.[2]

Obviously this is not the place for an extended discussion of the wisdom of our patent policy, but whatever

[1] *United States Senate Report*, No. 1263, p. 50. See also *Hearings*, *op. cit.*, pp. 207, 724.

[2] This situation seems to have been cleared somewhat through agreements reached by certain of the leading oil companies. In 1923 two of the more important suits (Rogers *vs.* Adams, and The Texas Company and Standard Oil Company of New Jersey *vs.* Pure Oil Company) were settled out of court under agreements reached by the interests concerned. Previously similar agreements had been reached between the Texas Company and the Standard Oil Company of Indiana, and between the Standard Oil Company of New Jersey and the Indiana Company. These agreements are said to have involved a pooling of the patents covering the Burton process controlled by the Standard Oil Company of Indiana, the Adams process controlled by the Texas Company, the Cross process controlled by the Gasoline Products Company, and the Ellis or Tank and Tube process controlled by the Standard Oil Company of New Jersey through its subsidiary, the Standard Development Company. On June 25, 1924, petition was filed by the Department of Justice in the United States District Court in Chicago naming the five companies controlling the patents as primary defendants (forty-four companies with licenses to use one or more of the above processes were named as secondary defendants) and charging violation of the Sherman Anti-Trust Act. While the petition is directed primarily toward the legality of the patent pool, the general nature of the petitioners' prayer for such 'further relief as the nature of the case may require and the court deem just' may lead to further examination and inquiry into the effectiveness of the dissolution decree of 1911.

its advantages may be, it seems clear that the policy has retarded the widespread and extended use of cracking in the refining of petroleum, and prevented to that extent a complete utilization of the more volatile and valuable petroleum constituents.

While the most important form of waste connected with the refining of petroleum is the incomplete utilization of the more essential products, the refining industry reflects under the urge of competitive enterprise many of the characteristics of the production industry. As previously stated, the development of new oil regions is followed by the construction of numerous refineries near the center of developments. Many of them are constructed by small stock companies for speculative purposes. Many possess no means of supplying themselves with the crude product. For example, of the 107 refineries in Oklahoma in 1919, 54 owned no tank cars with which to supply themselves with petroleum, 60 owned no pipe lines, and 44, representing an investment running up into the millions of dollars, owned neither pipe lines nor tank cars. It seems clear that many of these latter could not have been a commercial success. It is a safe conjecture that some few of these refineries have never turned out a barrel of refined products. In competition with the larger concerns which, in many instances operate their own crude production, transport their crude through their own pipe lines, and own their own tank cars, these small refineries are placed at a tremendous disadvantage. Often they are dependent upon local pools for their crude supply, are generally forced to pay a premium over the posted price of crude, and with declining production in the immediate locality are left high and dry. *The Oil Weekly* portrays such a situation in the fall of 1920 as follows:[1]

Reports from North Texas in the early fall indicate that the production in that section was not of sufficient volume to keep the

[1] *The Oil Weekly*, October 23, 1920, p. 123.

better refineries — large and small, running to capacity. In fact some of the smaller plants had been temporarily closed. Dallas, Fort Worth, and Wichita Falls with a possible daily refining capacity of 133,000 barrels of oil have been depending to a great extent on Burkburnett production for their crude. And the 85,000 barrels daily (Burkburnett production) was far from being enough even though every barrel found its way into refining stills. When you take into consideration the pipe-line runs, it becomes evident that possibly not more than 40,000 barrels of the already meagre 85,000 barrels of crude is refined locally.

Several refineries are complete in so far as construction is concerned but they lack that stuff from which refined products are drawn. Few are operating to capacity. Contracts for crude usually call for premiums, of more or less magnitude.

A similar situation is pictured by the same journal in Oklahoma:[1]

The refinery situation in Oklahoma is not dissimilar to that in Texas. . . . Refineries in Oklahoma, actually completed and operating, or capable of being operated, have a total daily capacity of 270,750 barrels. To this must be added 23,500 daily capacity which represents the total capacity being added to present plants. The capacity of plants under construction, according to late figures total 19,850 barrels. This gives a grand total of 314,100 barrels which will be the refining capacity of this State when additions and separate plants now under construction are completed.

One hundred and thirteen plants are included in *The Oil Weekly* figures. Toward the end of August, 77 of these plants were handling 161,000 barrels of oil a day. The total capacity of the 77 plants in operation at that time was 235,000 barrels. There was a capacity of 74,000 barrels a day not being utilized by the companies in operation.

From these figures it may be seen that only 68 per cent of refining plants, numerically speaking, were in operation at this time and those in operation were running only 68½ per cent capacity.

The Oil and Gas Journal in May, 1919, pictures a similar situation: 'It may be stated with considerable exactness that the 107 refineries in Oklahoma at the close of 1918 were actually using at the end of the year 35,000 to 40,000

[1] *The Oil Weekly*, October 23, 1920, p. 126.

barrels less crude than were the 69 refineries in Oklahoma in the summer of 1917. . . . The same mistake of overbuilding is being repeated in Texas. There were never so many refineries in distress in Oklahoma as now.'

Nor is this situation to be regarded as abnormal. From January 1, 1918, to January 1, 1922, the daily crude refinery capacity of the entire United States increased from 1,186,000 barrels to 2,164,000 barrels,[1] an increase of 978,000 barrels or approximately 82 per cent. And yet throughout the same period more than one fourth of the refinery capacity of the entire country remained unutilized. On January 1, 1922, there were 479 completed refineries in this country, the total daily capacity of which was 2,164,000 barrels. The average daily volume of crude run to the stills in 1922 was 1,371,000 barrels, approximately 64 per cent of the total capacity. Of these 479 plants only 311 were reported to the Bureau of Mines as in operation on December 31, 1922. During December, 1923, only 246 refineries were reported to the Bureau of Mines as operating. These plants were operating at 76.61 per cent of their aggregate capacity. During 1924, the average number of refineries reporting to the Bureau as operating each month was 265. These refineries operated on an average of 78.7 per cent of their aggregate capacity during 1924.[2] Unfortunately figures for the entire history of the petroleum industry are not available, but available evidence seems to indicate that the normal situation in the refinery business has been a considerable excess of refinery capacity over refinery output and that the situation has been accentuated by the extent to which competitive conditions have prevailed. Thus, at the time of the organization of the Stand-

[1] Including thirty plants under construction.

[2] The Bureau of Mines listed 555 refineries for the entire country completed or under construction November 1, 1924. Of these, 357 with a daily capacity of 2,480,922 barrels were reported as operating, 8 with a daily capacity of 18,200 barrels were reported as under construction, and 190 with a daily capacity of 333,410 barrels were reported as closed down. These last, of course, are not included in the above percentage.

ard Oil Company in 1870 there is said to have been a refinery capacity of three barrels to every one barrel of crude produced.[1] Excess refinery capacity is of course a normal situation and to be expected under competitive dynamic conditions. Granted the static state and frictionless competition, the situation could not have existed long. But society and the oil industry are dynamic and competition has lagged somewhat; always, however, there has existed enough competition to interfere with technical economic efficiency.

Thus it seems that reliance upon the influence of competitive forces has not insured an economical utilization of our petroleum resources. Uncontrolled production has encouraged and in some instances rendered imperative a wasteful utilization of the crude product. The crux of the whole matter is the uncontrolled private ownership and operation of a community resource which does not lend itself to the methods of competition. The speculative nature of oil production with its opportunities for tremendous enrichment has lead to the discovery of oil fields in advance of a genuine need. Exploitation under competitive methods has meant that the oil in these pools has been forced upon the market whether the market could readily absorb it or not. With too much oil on their hands, the business men have disposed of it as best they could. This has necessitated an incomplete utilization of our gasoline reserve in the consumption of oil for fuel purposes, with a corresponding waste of the heavier components useful for the lubrication of machinery.

Not only have we wasted a considerable portion of our resources through incomplete utilization, but we have expended more in accomplishing this result than has been necessary. There has been a duplication of plant and equipment to an extent scarcely justified by the task performed. There has been a large amount of unproductive capital tied up in idle equipment. On an individual and corporate

[1] Tarbell, Ida, *op. cit.*, vol. 1, p. 54.

balance sheet, this has meant an increased cost of operation and has been a potent cause of financial loss and failure. On the social ledger, it must be entered on the debit side of our account, representing a charge against industry and making for higher prices of petroleum products.

CHAPTER XIII

THE COMPETITIVE MARKETING OF PETROLEUM PRODUCTS

THE economic consequences of competitive methods in the development of our petroleum resources have been discussed in the preceding chapters. Competitive production, transportation, and refining of petroleum result in the incomplete utilization not only of the limited natural resource itself but of the industrial equipment by means of which these processes are accomplished. There remains for consideration the economic effects of competition in the marketing of petroleum and its products. Once crude oil has been concentrated and processed at the refinery, is the distribution of the refined products economically effected under a competitive system? In discussing the problem we shall approach it from the broader social point of view rather than from the narrower business viewpoint. The problem with which we are concerned is primarily a problem of industrial or social economy rather than a problem of technical efficiency in its narrow sense. It must be recognized at the outset, that in so far as the larger, more highly integrated companies are concerned, individual initiative and private competitive enterprise have attained a high degree of efficiency in the distribution and marketing of petroleum products. In the words of Mr. Pogue: 'To-day . . . we find the marketing of oil, with its preparatory steps of transportation and refining, to be a closely integrated enterprise, handling tremendous volumes of products, through diverging and ramifying channels of distribution of a unique and singularly efficient character.' [1] With their network of pipe lines, their fleets of tank steamers, their trains of tank cars, their myriads of tank wagons, trucks,

[1] Pogue, *op. cit.*, p. 212.

storage and filling stations, and pumps, many of the larger companies transport, process, and distribute petroleum and its products with singular dispatch and efficiency. Viewed as separate and distinct enterprises, many concerns have created marketing machines which run with mechanical precision. Oil, in its journey from the well in its crude state to the automobile or power plant, as refined gasoline or lubricant, meets with little interruption.

Variations occur in the marketing practices of the different companies, of course, but a marked similarity of method may be noted among the more important organizations. The following description gives a general picture of the marketing machinery by means of which the most important refined products are distributed.

Gasoline, in the main, is marketed direct to the consumer or retailer without the intervention of middlemen. At the refinery it is loaded into tank cars and shipped by rail to bulk or storage stations, which are scattered throughout the area served by a refinery and which are conveniently located with reference to local market areas. Where refineries are located on the coast, tank steamers are substituted for tank cars, since they afford a cheaper mode of transportation, and bulk or storage stations are located at strategic points along the coast. From these storage stations gasoline is transported by tank wagons or trucks to garages, filling and service stations, or to any one who purchases in tank-wagon quantity. Service stations may be operated by independent retailers or by employees of the larger marketing organizations. Of recent years a great many service stations have been installed by the larger companies, all middlemen having been eliminated in the marketing process. For example, the Standard Oil Company of Indiana, on January 1, 1923, operated 1668 service stations throughout its marketing territory.[1] During the first six months of 1922 the Shell Company of California marketed 44 per cent of the gasoline which it refined through its own service

[1] *Hearings, op. cit.*, part 3, p. 816.

stations. Similarly, the Standard Oil Company of California currently markets approximately 37 per cent of its gasoline through its own service stations. Of the balance not all is handled through dealers for re-sale, but a considerable proportion goes to the larger consumers, such as ranchers or large farm operators.

In recent years many of the marketing companies have devoted considerable attention to the measurement of the size and geographic disposition of the various demands for petroleum products in order to eliminate waste effort in distribution and salesmanship. Service stations are usually located on the basis of the number of automobiles that pass. The expansion of marketing equipment has proceeded in part upon the exact measurement of the consumptive requirements of the territory to be served, and wide use has been made of the registration figures for automobiles and trucks in order to determine the requirements for gasoline.[1]

By such systematic and scientific procedure, the efficiency in marketing organization to which Mr. Pogue refers has been attained. Viewed as separate units little fault can be found with the marketing systems which the leading oil companies have constructed. But when regarded from the broader industrial and social point of view serious defects appear. Maladjustment, overlapping, and duplication result from the competitive effort of numerous marketing organizations to place their branded products in the hands of the consumer.

In 1911 at the time of the dissolution of the Standard Oil Company of New Jersey, that organization marketed about 90 per cent of the petroleum products manufactured by refineries in this country. Since 1911 the percentage of total traffic in refined products of the combined Standard group has decreased to approximately 50 per cent. When it is recalled that the total volume of traffic has increased several fold during the same period, the increased importance of the

[1] Pogue, *op. cit.*, p. 221.

independents as a group may be more fully appreciated. The full competitive significance of the present situation can be grasped only by noting that the traffic handled by independents is divided among hundreds of concerns ranging in size from the smaller refineries which have a daily capacity of only a few hundred barrels and cater to a local retail or jobbing trade, to the large, highly integrated companies which do a distribution business throughout every portion of the United States.

It will be recalled that previous to its dissolution, the Standard had divided the United States into eleven marketing divisions in order to secure efficiency in distribution and administration. In each of these divisions a separate company handled the marketing of refined products. These eleven companies were among the thirty-three coming under the dissolution decree. Previous to the dissolution they had functioned as separate concerns, each in the territory occupied by it at the time of the decree. As explained above, these eleven marketing areas have been maintained by the dissolved Standard units, and since the dissolution, with the few exceptions noted, there has been no competition between the old Standard companies. Such a division of territory permitted a strategic location of refineries and the creation of storage stations and transportation facilities conveniently located with reference to the chief population centers within each geographic area. The sharp lines of cleavage between the territories served by the various Standard companies prevented duplication of machinery and made possible the creation of an economical and efficient marketing organization.[1] Similarly other companies since the Standard dissolution have divided the country into

[1] There is intended no suggestion that such a division of marketing territory and its organization under separate companies was effected solely for economic efficiency. On the contrary, as pointed out in the early pages of the discussion, such a division seems to have been made in part to facilitate monopoly control through practices which under latter-day business ethics are considered unfair, e.g., it made easy a careful espionage over the business of competitors.

convenient units with reference to refineries, transportation facilities, and population centers in an effort to construct efficient marketing organizations. The success of these efforts is voiced by Mr. Pogue in his description of the petroleum marketing machinery as 'unique and singularly efficient.' But the gain in efficiency has been secured at a sacrifice in economy. The competitive effort of hundreds of business concerns [1] directed toward the same end has resulted in tremendous duplication of equipment and sales effort and has thereby injected into the petroleum marketing machinery, when viewed in its entirety, a substantial element of waste.

Such duplication of machinery, while prevalent in all stages of the marketing process is particularly patent at the last stage — in the delivery of the product to the consumer. The frequent location of competing service stations on adjoining street corners is an illustration in point. It is impossible to make a precise quantitative statement of the extent of waste through duplication of filling stations and pumps. Not only is there a paucity of data, but the problem of measuring waste in marketing petroleum is complicated by imponderable factors.[2] However, a description of the manner in which duplication has developed indicates something of its extent. In the early history of the industry kerosene and gasoline were retailed in large part by local retailers, principally the grocery store. With the advent of the automobile the installation of underground tanks

[1] In this regard the situation in the State of Ohio is interesting and pertinent. In that State the Standard Oil Company of Ohio has some 300 bulk distribution stations and 410 service stations for the retailing of gasoline. Two hundred competitors share the business of the State with the Standard, operating from 375 to 400 bulk stations and more than 100 service stations.

[2] For example, the apparent excess of service stations may represent in part the effort of competing petroleum refiners to meet the fastidious demands of exacting and discriminating purchasers for different brands of gasoline. However, the existence of such diversity of demand is, in the main, the result of competitive advertising, and this in itself from a social point of view is largely waste.

and roadside and curbside pumps resulted in greater convenience and safety to the motorist. Increasing competition, particularly in the sale of gasoline, coupled with a desire on the part of the large companies to maintain as great control as possible over the product until it reaches the hands of the consumer, has led to the practice of leasing pumps to garages, service stations, and roadside dealers. The system varies in different sections of the country, but in general pumps and underground tanks are installed for local dealers at the expense of a marketing company with the understanding that only gasoline bearing its trade name will be sold through the pump.[1] A nominal rental, usually of one dollar per year, is charged for the use of the equipment. Complete statistics are not available but the extent to which this practice prevails may be indicated by a few concrete figures. In 1920 the Atlantic Refining Company loaned 2122 pumps. In 1921 it loaned 2056 pumps and in 1922 it loaned 2513 pumps.[2] The Standard Oil Company of New York at the close of 1922 had leased or loaned equipment to about 19,000 dealers in New York and the New England States.[3] This equipment was carried on the companies' books at a value of $4,500,000. The Sinclair Refining Company up until the close of 1922 had leased 1617 units of equipment representing an investment of

[1] The Federal Trade Commission in October, 1919 (Federal Trade Commission *vs.* Sinclair Refining Company), held that the practice of leasing pumps and equipment for a nominal rental, which does not afford a reasonable profit on the investment, on the condition that the lessee use the equipment only for handling the products of the lessor, is an unfair method of competition in violation of Section 5 of the Federal Trade Commission Act and Section 3 of the Clayton Act. (See *Federal Trade Commission Decisions*, vol. II, p. 127.) The Commission issued a cease and desist order. The Sinclair Refining Company petitioned the Circuit Court of Appeals, Seventh Circuit, on September 8, 1921, to review this order of the Commission. The Court held the leasing practice not an unfair method of competition. (See *Federal Trade Commission Decisions*, vol. IV, p. 552.) The case was carried to the Supreme Court and a decision handed down in April, 1923. The Court was unanimous in overruling the Commission's order.

[2] *Hearings, op. cit.*, part 3, p. 567. [3] *Ibid.*, part 2, p. 308.

$375,000. Nor is the practice confined to the few companies mentioned. On the contrary it is quite general with both the Standard companies and the larger independents throughout the greater portion of the United States. This practice has resulted in a multiplicity of unnecessary filling stations which represent a tax upon the industry — a tax which manifests itself in the form of higher costs with lessened profits or in higher prices. In this regard Mr. L. V. Nicholas, president of the National Petroleum Marketers' Association, testified before the Senate Committee as follows:[1]

> I would say that the overequipment, the overdevelopment, and overinstallation of equipment in the oil business is the greatest handicap that the business and public have to-day. It is almost incredible. I would venture the statement that with the curb pumps and filling stations installed in the United States at the present time, if there is not another tank put in or another pump put in, or another filling station put in, except for replacement, the industry would not be overloaded to take care of the demands from now on for ten years to come with an increase of ten per cent in volume each year or better.

The present excessive investment represents to Mr. Nicholas a 'tragic overhead, that is unjustified and unnecessary.'

Many of the pumps, of course, may be but the combined expression of the motorists' demand for convenience and the industry's initiative in grasping a business opportunity. But the practice has resulted in a situation teeming with waste. Conditions in the State of New York have been effectively described by Mr. Albert Matthews, president of the New York State Petroleum Marketers' Association, in the following words:[2]

> . . . The installation of these pumps in the municipalities and along the roadsides has gone to the point now where it is quite possible that it will have to be curtailed by the State municipal authorities. In New York State at the present time, the State road authorities are refusing to permit any additional installations of pumps on the State road property itself, and a very considerable

[1] *Hearings, op. cit.*, p. 573. [2] *Ibid.*, p. 602.

number of municipalities have refused to install any more pumps on the curbstones. In some cities there is some movement on foot to endeavor to take out some of the pumps already installed.

Nor are the larger companies themselves unaware of the evils which the practice has entailed. The president of one of the larger oil companies in the United States writes as follows: [1]

I am quite sure that if the industry could turn the hands of the clock back twenty years it would avoid the present wasteful system of gasoline marketing. As you surmise, there is a great deal of unnecessary duplication in garage and roadside filling stations. The result is patent to any one who rides. At remote four-corner settlements, you will find a dealer with four tanks and four pumps and not selling enough gasoline out of any one of them to pay interest on the cost of installation. In more congested districts it is rare indeed to find a station where the pumps are used to anything like their capacity. There are altogether too many people retailing gasoline and they have too many tanks and pumps for the business they do.

The blame lies at the door of the man who started loaning equipment at the nominal rental of one dollar per year. This made it possible for thousands of people with no real capital to set themselves up as dealers. Of course, other companies made haste to follow the lead of the pioneer in this game and I suppose that if one company had not started the practice another would have done so.

I believe in competition. When you take the competition out of business you take the fun out of it. But when competition reaches the point of overlapping of services the consumer must bear the enormous loss. Thus, the multiplicity of filling stations, the fierce race for business which has characterized the marketing of gasoline in the past few years particularly, means competition overdone, but it does not mean that competition is not the very best and most wholesome thing in business.

Waste through duplication is much less evident in the marketing of kerosene than in the marketing of gasoline, due in part to the difference in the nature of the demand. Since it is used for domestic purposes, largely for light and fuel, the service station is unimportant in its distribution. The major portion of the domestic consumption is distributed

[1] Personal communication.

through the agency of the tank wagon or the tank station and the retail grocery store. Since the production of kerosene has been almost continuously in excess of domestic needs special emphasis has been placed upon foreign marketing. The traffic is carried on in large part by a few of the major companies, consequently much waste through duplication has been prevented.

The distribution of fuel oil differs greatly from that of gasoline and kerosene. Since it is consumed, in the main, in bulk by large industrial establishments, railroads, and steamships, the machinery for the distribution is relatively simple. It is sold in most part under direct consignment from the refinery to the consumer, and duplication of marketing facilities is much less evident than in the case of gasoline.

Lubricants present still a third type of marketing which grows out of the particular problems involved.[1] These products are highly fabricated to meet the specialized demand of a wide range of machine types. They are individual products requiring individual treatment in their placement where needed. They are in part handled through service stations and by tank wagons to garages and stores, but a large percentage of the total volume is designed for industrial service and is sold direct to the industrial establishments. Due to the technical problem of correct lubrication, sales effort frequently involves the assistance of lubricating engineers familiar with the characteristics of a particular oil and the demands of particular machines. A considerable volume of lubricating oils is handled by jobbing interests. Base oils are purchased and compounded into special grades and sold under trade names. Competition among refiners and jobbers has resulted in a confusing multiplicity of brands and an extensive range of advertising with specialized sales effort. Much of this effort, whatever may be its value to particular companies, from a social viewpoint represents waste.

[1] *See* Pogue, *op. cit.*, pp. 221–22.

Thus it seems true that competition has developed a great number of effective channels for the distribution of petroleum products. It may be granted that individual initiative, the price urge, and the profit motive have made for efficiency within these various channels if they are considered as isolated and independent industrial units, but these same factors when manifested by hundreds of competing concerns have resulted in such excessive duplication of equipment and sales effort that the petroleum marketing machinery, when viewed as a component part of a complex industrial system is uneconomical, wasteful, and inefficient.

CHAPTER XIV

THE DISPOSITION OF OUR NATIONAL PETROLEUM LANDS

We have relied entirely upon the forces of private, competitive business enterprise to ensure an economical and efficient utilization of our petroleum resources. In an industrial society the foundations of which are built upon the institution of private property, competitive exploitation of petroleum on a property basis has been a normal development. Most of the petroleum lands of this country are privately owned, and the vested rights thereto are not only natural, i.e., institutional, but they are protected by definite legal provisions. The small individual landholder in the exercise of his legal rights has presented a serious obstacle to unified direction and control and has thereby been a contributing factor in the development of existing technique in petroleum production. But it has been within the power of the Government, without doing violence to the existing order of things, to protect in a measure our petroleum resources at one important point. There has remained until quite recently a vast area of undeveloped lands within the public domain. In its disposition of those portions of the public lands which are rich in discovered or potential oil reserves, it has been within our Government's power, without additional legislation or constitutional change, to exercise complete control over the exploitation and utilization of the underground petroleum supply. In view of the tremendous shrinkage which our domestic reserves have experienced in recent years and the growing conviction of an approaching domestic shortage, this opportunity assumes magnified importance. How have we met this responsibility?

Prior to the act of February 25, 1920, title to public lands

of the United States, containing or supposed to contain petroleum, could be obtained only under the mining-placer law. Under this law twenty acres formed the unit of a placer claim. Tracts of 160 acres could be claimed by an association of eight locators and there was no limitation upon the number of 160-acre locations which might be made. With the growing recognition of the social importance of petroleum and the limited nature of our domestic reserve, an administrative policy of conservation developed and took the form of withdrawals of public lands supposed to contain petroleum. Mining claims could not be located upon these withdrawn lands. Prior to the opening of the present century no withdrawals of importance had been made. Extensive withdrawals, however, were made in 1900 and 1901, but subsequently restorations were made from time to time, until by 1908 most of the lands so withdrawn had been restored. In the latter part of 1909 under the Taft Administration some 3,000,000 acres were withdrawn in California and Wyoming by executive order. Prior to June 25, 1910, withdrawals had been made under the authority of the Commissioner of the General Land Office or by executive order, without direct legislative authority or confirmation. On that date, however, Congress enacted a law directly authorizing the President to make withdrawals of land for classification and for various other purposes, and confirming his authority as to the withdrawals already made. Since that date there have been numerous further withdrawals and restorations; but on December 1, 1921, there remained in the public petroleum reserves a total of 6,612,138 acres of land in the States of Arizona, California, Louisiana, Montana, North Dakota, Utah, and Wyoming.[1]

On February 25, 1920, the President approved an act of Congress to promote the mining of coal, phosphate, oil, oil shale, gas, and sodium on the public domain. The act

[1] It should be noted, however, that these areas include considerable land, title to which is claimed by individuals.

provides the form and manner in which the public petroleum lands may be disposed of to private individuals for purposes of exploitation. Although the act sets forth broadly the principles under which leasing may be conducted, the Secretary of the Interior was authorized to prescribe the proper rules and regulations under which the provisions of the act shall be administered. We shall not attempt here a detailed analysis either of the law or the rules and regulations under which it is administered. We do wish, however, to point out and emphasize a fundamental defect in this legislation. Although it marks a distinct improvement upon other bills introduced at an earlier period in Congress, it fails to take complete account of the fundamental nature of petroleum and its occurrence.[1] The act and its administration seem to be designed to ensure competitive conditions in the production and sale of minerals secured from the public domain.[2] It fails to recognize the fact that the only logical unit for exploiting an oil pool is the geological unit — the underground pool itself. It is a well-known fact that the occurrence of oil has no relationship to legal surveys or surface boundary lines, that it is a migratory mineral, and yet we legally ignore its migratory nature and in effect attempt by fiat to force oil to recognize legal divisions and subdivisions of public land surveys.[3] The law as it stands seems to be inade-

[1] The act provides that land shall be granted for prospecting purposes in areas not to exceed 2560 acres. If petroleum should be discovered on tracts so granted, the prospector shall be entitled to a lease of one fourth of the land embraced in the prospecting permit, provided that the prospector shall be granted a lease for as much as 160 acres. The act further provides that where unappropriated deposits of oil or gas are situated within the known geologic structure of a producing oil or gas field the unentered lands may be leased by the Secretary of the Interior to the highest responsible bidder by competitive bidding in areas not exceeding 640 acres. See Sections 13, 14, and 17, *An Act to Promote the Mining of Coal, Phosphate, Oil, Oil Shale, Gas and Sodium on the Public Domain,* S. 2775 No. 146, 66th Congress, approved February 25, 1920.

[2] See Section 30 of Act and Section 3 (d) of form of lease.

[3] See Sections 13 and 14.

quate to ensure an orderly development of our petroleum reserves.[1]

Likewise, in disposing of oil and gas rights on the lands of our Indian wards under legal authority granted by the act of June 28, 1906, and subsequent legislation, our Federal Government, through the Department of Interior, under the rules and regulations adopted, has failed in a similar manner to take account of the fundamental geological conditions under which oil is found. Regulations have varied somewhat with the different tribal lands, but in general land in proven territory has been leased in small blocks, frequently of 160 acres, under competitive bidding at auction. In an endeavor to prevent the establishment of monopolistic conditions the size of total holdings within any one reserve has also been limited. Thus, both in the disposition of our national domain and of the restricted lands owned by our Indian wards, we have failed to take complete cognizance of the geological occurrence of petroleum, and for that reason our legislation and regulations have been inadequate to ensure an orderly, efficient, and economical development of the public petroleum lands.

The passage of the Leasing Act of 1920 marked the beginning of the policy of exploitation of our public petroleum lands which culminated in the recent leasing of the last of our more important naval petroleum reserves. These reserves, three in number, were created by executive order out of lands formerly withdrawn as general petroleum lands.[2] Reserve No. 1, which includes approximately 38,000 acres in Elk Hills, California, was set aside on September 2, 1912; Reserve No. 2, which includes approximately 30,000 acres in Buena Vista Hills, California, was set aside on December 13, 1912; and Reserve No. 3, which

[1] Subsequent developments indicate that the act was also untimely. It threw open to immediate exploitation millions of acres of potential oil lands at a time when the country was entering upon a period of overproduction.

[2] Two shale-oil reserves were likewise created, one in Colorado and one in Utah.

includes approximately 9500 acres near Salt Creek, Wyoming, was set aside on April 30, 1915.

There seems to be general agreement that the original purpose for which the federal petroleum lands were withdrawn and the naval reserves subsequently created was to guarantee our Navy a supply of fuel oil for such future time when an adequate supply from the regular channels of commerce would not be readily forthcoming. The naval reserves were intended to be in the nature of an insurance policy, a protection for the future when commercial supplies of petroleum would no longer prove sufficient to meet the widening demands placed upon them.[1]

The wisdom of such a policy has been confirmed almost unanimously by those who have seriously considered the problem. In view of the growing importance and increasing volume of the demands for naval fuel oil and the rapidity with which our domestic reserves are being exhausted under the influence of unrestricted competitive enterprise, the preservation of the fuel-oil reserve seemed imperative to ensure the efficient functioning of our first line of defense in a time of national peril. Far-sighted national policy seems to have demanded that every barrel of this oil remain underground as long as any other source of oil in the world was available, provided, of course, that keeping the oil in the ground did not mean that it would be lost to private individuals through outside drilling.

Such a policy of conservation seems to have been followed consistently from the time of the creation of the reserves under the administration of President Taft in 1912 until the incoming of the Administration in March, 1921. The attitude of the Navy Department toward these reserves, which seems to have persisted throughout this whole period, is well summarized in the Annual Report of the

[1] See testimony of Dr. George Otis Smith before the Senate Committee on Public Lands, *Hearings before the Committee on Public Lands and Surveys, U.S. Senate, 67th Congress*, part 5, pp. 1227–28; also excerpts from Annual Report of Secretary of the Navy, 1914, 1915, 1916, *ibid.*, pp. 157–58.

Secretary of the Navy for 1916.[1] 'It was the intention to hold these areas which could wisely be conserved in reserve and not utilize their oil content until the shortage of domestic production or the increased price of fuel oil rendered it advisable. These reserves were designed to serve as an insurance against the possibility of having a large fleet of exclusively oil-burning ships with no oil available.'

Although this attitude seems to have been tenaciously held by the Department of the Navy from the time the lands were first set aside despite repeated efforts on the part of our congressmen to throw these reserves open to private exploitation,[2] the difficulty of carrying out this policy without some modification was recognized soon after the creation of the reserves. The reserves were created from lands presumably owned by the Federal Government, but private individuals laid claim to certain portions of each of them. In the case of Reserve No. 2, practically every acre was claimed 'under some form of asserted rights, varying in character from title in fee simple, established by patents, to "paper locations" of no value, and many tracts were claimed by more than one individual as the land had been covered many times by "paper locations."' [3] In 1916, of the total of forty-seven sections within the reserve, more than twenty-nine sections were patented as mineral lands and privately owned. Of the unpatented lands there were private claimants to all but 2240 acres.[4] Private title to some of this land had been definitely established prior to the Leasing Act of February, 1920,[5] and exploitation for oil had been under way for several years. In commenting upon conditions in this reserve in 1920 the Secretary of the Navy in his annual report had the following to say: 'Owing to its

[1] *Hearings, op. cit.*, part 1, p. 158; *Report of Secretary of the Navy, 1916*, p. 31.

[2] See *Hearings, op. cit.*, part 1, p. 167.

[3] *Ibid.*, p. 165, quoted from *Proceedings*, United States Naval Institute, 1916.

[4] *Ibid.*, p. 58.

[5] Senate Document No. 210, p. 6.

physical contour and to the scattered location of the various producing wells, it is questionable whether Reserve No. 2 can be maintained as a reserve without a great loss of the oil contents due to drainage by the present producing wells and by wells drilled by operators outside the reserve.' [1]

The situation in Reserves No. 1 and No. 3, however, was much more satisfactory from the Government's viewpoint. Reserve No. 3, in view of the fact that it included an area larger than the geological structure and because of the apparent invalidity of all private claims, had been considered by the Navy Department as an ideal reserve. Reserve No. 1, while it was supposed to be fairly well protected, included approximately 9¼ sections of privately owned lands. Section 36, near the heart of the reserve, was controlled by the Standard Oil Company of California. A large oil well had been completed by this Company as early as 1919 and subsequent to that date additional wells had been drilled. These wells were unquestionably a menace to the integrity of Reserve No. 1. In view of the danger of drainage from these privately owned wells, the Department of the Navy considered it expedient that it be given full authority to take such measures as might be deemed necessary to protect the reserves, in so far as possible, from loss by private operations. Accordingly, the Act of June 4, 1920, making appropriations for the naval service for the fiscal year ending June 30, 1921, provided that the Secretary of the Navy be directed to 'take possession of all properties within the naval petroleum reserves as are or may become subject to the control and use by the United States for naval purposes, and on which there are no pending claims or applications for permits or leases under the provisions of the act of Congress approved February 25, 1920, etc., to conserve, develop, use, and operate the same in his discretion, directly or by contract, lease, or otherwise, and to use, store, exchange, or sell the oil and gas products

[1] *Hearings, op. cit.*, p. 161, quoted from Report of Secretary of the Navy, 1920, p. 143.

thereof, and those from all royalty oil from lands in naval reserves, for the benefit of the United States.' [1] This provision of the act was secured at the request of the Navy Department apparently for the purpose of protecting more adequately the Government's equity in its underground store of petroleum.

Soon after the passage of the act, steps were taken to secure the drilling of wells in Reserve No. 2 as a measure of protection from drainage. For this purpose two leases were signed by the Secretary of the Navy. One provided for the drilling of five wells and the other for the development of 120 acres. Steps were also initiated to effect the drilling by private contract under competitive bids of twenty-two wells within naval Reserve No. 1 to protect it from the danger of loss by the privately operated wells. It is doubtful that these measures were adequate to accomplish their object; but that a more comprehensive programme of development was not undertaken immediately is indicative of the attitude of the Navy Department toward the policy of conservation initiated under President Taft's Administration almost a decade before. The Navy Department seems to have been unwilling to sacrifice needlessly any portion of this land. Its dogged reluctance to part with one barrel of the public's stock of oil was proverbial. Secretary of the Navy Daniels has been severely criticized and denounced by men in the oil industry because of this unwillingness to grant extensive leases within these reserves.[2]

While the Navy Department seems to have consistently regarded the conservation of these Government petroleum lands as essential to an adequate programme of naval defense, it should be observed that in its effort to retain these reserves intact, it has not always had the sympathetic

[1] 41 Stat. 813.

[2] See the testimony of Mr. Doheny, *Hearings*, *op. cit.*, part 7, p. 1953. We are not attempting to defend Secretary Daniel's policy or his programme, but merely to indicate the attitude toward these reserves which seems to have been insistently held by the Navy Department for a period of more than a decade.

coöperation of either Congress or the Department of the Interior. Despite the apparent national necessity of a policy of conservation, it has been difficult for the Navy to retain control of these reserves. Since the original orders of withdrawal there has been an almost uninterrupted contest with the oil operators for their possession; in this contest the Department of the Interior and some of our congressmen have not infrequently placed the weight of their influence on the side of the operators. Thus, since the issuance of the original orders of withdrawal, numerous bills have been introduced in Congress from time to time looking to the relief of private operators on unpatented lands within the reserves, and quite generally these bills have not afforded adequate recognition of the Navy's rights to these lands. In 1914 three bills were introduced in the Senate and three in the House of Representatives providing for the disposition of the public petroleum lands or the oil and gas produced therefrom. From the Navy's viewpoint [1] none of these bills, as introduced, provided adequate means by which the Navy might secure oil from these reserves or be reimbursed for the oil drawn from the lands specifically set aside for the 'exclusive use or benefit of the United States Navy.' In spite of their failure to meet with the approval of the guardians of these treasured resources, these bills seem to have had the unqualified approval of the Secretary of the Interior. The Secretary's attitude toward these reserves is evidenced in the following statement taken from his letter written in 1914 to the Chairman of the Committee on Public Lands of the House in regard to H. R. 15,661, then under consideration. 'This measure will, in my opinion, not only afford relief to operators who, as stated, have in good faith made large expenditures in the development of oil or gas from such lands, but will operate to relieve the Land Department from a large amount of expense and work in investigating and adjudicating claims to such lands presented under the general mining laws. . . . I recom-

[1] See *Hearings*, *op. cit.*, part 1, p. 167.

mend the enactment of H. R. 15,661.'[1] This declaration of approval evidences a complete failure to comprehend the broad purposes for which the original withdrawal of these lands was effected. That the Attorney-General manifested a more public-spirited viewpoint toward the proposed measure is evidenced by his criticism expressed in a letter to the Secretary of the Interior. He said: 'I entertain grave fears that the practical effect of this bill, if enacted, would be to destroy the effect and thwart the purpose of the withdrawal order.'[2]

The incoming of the new Administration in 1921 marked a change in procedure in the administration of the petroleum reserves which culminated in the opening up of the entire acreage of Reserves No. 1, No. 2, and No. 3 to immediate exploitation under private operation on a royalty basis. On May 31, 1921, the administration of the naval reserves was transferred by executive order from the Department of the Navy to the Department of the Interior. The ostensible purpose of this transfer was to ensure a more intelligent disposition of the special problems which might arise in connection with the general problem of protecting the reserves from loss by privately drilled wells. Secretary Denby seems to have felt that the Department of the Interior was the proper department 'to protect and conserve the naval oil reserves of the United States.' In a letter addressed to the President on May 26, 1921, he states:[3] 'It seemed to me that that department, being charged with the custody of all other public lands of the United States and being fully equipped to handle the public lands, is the more appropriate department to protect the interests of the Navy in oil lands.' Although this avowal represented the conviction and judgment of the Secretary of the Navy, in view of the radical departure which the subsequent disposition of these reserves marked over the traditional policy of conservation persistently pursued hitherto by the De-

[1] *Hearings, op. cit.*, p. 167. [2] *Ibid.*, pp. 167–68.
[3] *Ibid.*, p. 286.

partment of the Navy, it is interesting and pertinent to note that in arriving at this decision the Secretary did not consult, as regards either the legality or the desirability of this transfer, the General Board of the Navy Department, his council consisting of the chiefs of bureaus, the Judge Advocate General of the Navy, nor the naval officer in charge of petroleum reserves. He did consult informally Rear-Admiral R. S. Griffin, Chief of the Bureau of Steam Engineering under whose direction the oil reserves had been handled up to that time, and the Rear-Admiral advised strongly against the transfer and predicted that if the transfer were effected the Navy might 'just as well say good-bye' to its oil. The Secretary, in divesting himself and his department of the duties which had been imposed upon and entrusted to him by Congress seems to have relied solely upon his own judgment despite considerable opposition from other members of his department more closely in touch with the fuel-oil needs and policy of our Navy.[1] The Secretary himself testified that he could not recall any officer of the Navy Department other than himself who approved of the transfer of jurisdiction over the reserves to the Department of the Interior.[2]

The transfer of authority over the reserves was effected on May 31, 1921. Within less than two years from this date practically the entire acreage of Reserves No. 1, No. 2, and No. 3 had been leased to private operators for immediate development. Prior to this date the Navy Department had given notice that bids would be received for the drilling of offset wells on Reserve No. 1 along the entire north boundary of Section 1, to offset the drainage because of the production of Standard Oil wells on the south boundary of Section 36. On July 12, 1921, a contract was awarded to the Pan-American Petroleum and Transport Company for the construction of these wells, since this

[1] See testimony of Admiral Robison, *Hearings*, *op. cit.*, part 4, p. 896.

[2] *Ibid.*, part 2, p. 288.

company had made the highest and most advantageous bid.

Shortly after the executive order of May 31, 1921, was issued, the Secretary of the Interior discussed with the Bureau of Mines the advisability of a more extensive leasing programme as a measure of protection against further drainage. Some time in October, 1921, a general conference was held in the office of the Secretary of the Interior and the problem was considered more in detail. There were present at this conference, among others, the Secretary and First Assistant Secretary of the Interior, and the Director and Chief Petroleum Technologist of the Bureau of Mines. According to Director Bain of the Bureau:[1]

> It was the consensus of opinion that nothing could be gained by further attempt to hold in the ground any of the oil remaining in reserve No. 2. . . .
>
> As to Reserve No. 1, it was recognized that serious drainage was then taking place and would spread gradually to the depletion of or rendering unavailable the oil in much, if not all, of the reserve. Pending formulation of a general policy as to exchange of oils, the Bureau was directed to select *lands forming temporary protective strips in Reserve No. 1*,[2] and all lands in No. 2 for which lessees seemed likely to be found and in coöperation with the General Land Office to prepare papers inviting proposals for the lease of such lands.

At this conference the situation as regards Teapot Dome, or Reserve No. 3, was also discussed in general terms, and the Bureau recommended that no action affecting Reserve No. 3 should be taken until further data were gathered.

It will be recalled that Reserve No. 2 was largely owned by private individuals whose holdings were indiscriminately intermingled with the areas belonging to the Government. Exploitation had been in progress on tracts within and adjacent to this reserve for a number of years. Prior to March, 1921, there had already been drilled 408 oil and gas wells on patented lands within the reserve, 141 wells on Government lands within the reserve claimed by private

[1] *Hearings, op. cit.*, p. 1123. [2] Italics mine.

individuals under the mining law, 142 wells on patented lands adjacent to the reserve, and 33 wells on Government lands adjacent to the reserve. Subsequent to the conference in October, 1921, the Department of the Interior, following the recommendations of the Bureau of Mines, has consistently pursued a policy of rapid exploitation and most of the productive area not previously exploited has since been leased on a royalty basis.

Meanwhile a plan had been worked out by the Department of the Interior whereby the royalty (oil) secured from wells drilled on the reserves under provisions of the Leasing Act of 1920, together with royalty (oil) secured by wells drilled under the newly adopted leasing programme of the Department, should be received in kind to be exchanged for fuel oil. It should be pointed out that at that time the Government owned no storage facilities adequate to carry out a programme of this sort. To the Secretary of the Interior, however, this was no obstacle. As a part of the plan the Secretary invited proposals for the acceptance of royalty oil accruing to the Government from leases in naval petroleum Reserve No. 2 in exchange for storage facilities to be provided by the successful bidder at Pearl Harbor, Honolulu, together with 1,500,000 barrels of fuel oil.[1] The successful bidder was to bear all the expenses of construction, to furnish all the labor and materials needed, and to fill the storage when completed with fuel oil of a specified grade. The successful bidder was to be reimbursed for the expenses of construction in royalty oil at the market field price of oil of the gravity delivered at the time of production. In response to this proposal preliminary sketches of the desired storage facilities were submitted in the early part of 1922 to three companies which had signified a will-

[1] The writer does not purpose to pass judgment upon the advisability of such a programme of construction from the viewpoint of our Navy's needs. He ventures the suggestion, however, that an extensive programme of construction of this sort might well have been financed by appropriations from Congress rather than at the expense of the naval oil reserves.

ingness to bid. Bids were returned on March 1, 1922, and it was determined that the Pan-American Petroleum and Transport Company had submitted the lowest bid. It should be noted that the Pan-American Company submitted two bids, both of which were lower than the other bids received. One of the bids of the Pan-American Company was in strict accordance with the provisions of the proposal submitted by the Secretary of the Interior to the oil companies which had signified a willingness to submit bids; the other was an alternative bid. According to the alternative bid, which was labelled Bid B, the Company expressed a willingness to erect and fill the storage at Pearl Harbor for some 213,800 barrels of oil less than the amount specified in Bid A. The Company further agreed, should this bid be granted, to give the Government any advantage which might result in the construction and erection of storage facilities for lesser cost than represented by the number of barrels of oil used in estimating the cost of erection and construction of the storage facilities. This alternative proposal was made, however, on condition that if it be accepted the Secretary of the Interior agree to give the Pan-American Petroleum Company a 'preferential right to lease from the Government any lands within the naval petroleum Reserve No. 1, California, which the Government may decide to lease.' Proposal B was accepted, and the agreement was signed on April 25, 1922.[1] At the same time it was agreed that the Department of the Interior would grant to the Pan-American Petroleum and Transport Company within one year from the date of the delivery of the contract leases, two small leases on Reserve No. 1. These additional leases apparently were not granted for purposes of protecting the reserve from drainage, but, according to Director Bain of the Bureau of Mines who

[1] *Hearings, op. cit.*, p. 1168. Upon recommendation of Mr. Ambrose of the Bureau of Mines, the preferential right was restricted to the east half of the reserve. Subsequently, however, when the lands were thrown open to development and the preferential right exercised, the Secretary of the Interior leased the whole area to the Pan-American Company.

consulted frequently with the Secretary of the Interior regarding the entire project, they were granted in 'order to increase the amount of royalty oil that would accrue and become applicable on the contract, and by so much, shorten the time the contractor would need to wait to secure a return from the money he agreed to spend immediately to construct storage facilities.' [1]

A few months after the execution of this agreement, in August, 1922, Mr. Doheny, president of the Pan-American Oil Company, submitted to the Secretary of the Interior a memorandum in which he called attention to the gross overproduction of petroleum in California and the consequent demoralization of the market. Mr. Doheny pointed out that since May 14, 1920, the basic price of crude oil had been reduced from $1.60 to 60 cents per barrel and that 'as a result of this lowering of the basic price, the selling price of the Government royalty from the wells operated by its lessees in California has been reduced approximately $250,000 per month, or approximately $3,000,000 per annum.' [2] This meant, of course, that the construction work at Honolulu would cost the Government more in oil than had been anticipated at the time the enterprise was launched. Mr. Doheny apparently regretted that the fortuitous circumstances of temporary overproduction should thus indirectly operate to rob the Navy of a portion of its equity in its treasured reserves. But he saw in this situation an opportunity to expand and widen the scope of his already extensive operations in the oil industry. Mr. Doheny, in expressing his view of the situation to former Secretary Fall, frankly states: [3]

> It suggests that an opportunity exists for the investment by those having experience and confidence in the business in an additional enterprise, which will help obviate the present handicap of such producers. It is expected that the present relations between the daily oil production and the capacity of the refineries

[1] *Hearings, op. cit.*, p. 1128. [2] *Ibid.*, p. 1175.
[3] *Ibid.*, p. 1176.

on the Pacific Coast will continue for a considerable period, and that the handicap which the producers operate under can only be relieved by the broadening of the market to an extent that is justified by the present increased production.

He accordingly proposed to construct immediately from two to five million barrels of steel and concrete storage in California and 'immediately upon the completion of a substantial part of the above storage to commence the taking of oil from the existing supply at such rate as will keep pace with the completion of the storage tanks and reservoirs.' 'This,' said Mr. Doheny, 'will immediately arrest the downward tendency of prices in oil.'

Mr. Doheny further proposed to begin immediately the construction of a refinery with an initial capacity of 10,000 barrels per day to be increased to 20,000 barrels per day as the situation justified. He stated that this refinery would be ready for operation in from six to eight months. He also proposed to construct private pipe lines and transportation facilities from the sources of supply to the refinery and storage plant. In commenting upon his proposed venture, Mr. Doheny wrote as follows:[1]

It is estimated that this new venture will necessitate the expenditure of approximately $10,000,000. It can only be justified if those who undertake to carry it out have confidence in the assurances which the different fields offer of a sufficient supply of oil to keep the refinery operating to capacity.

There are two reliable sources of supply for oil that might be used in connection with such an enterprise to the great advantage of the controllers of those sources. The one is the Government royalty oil from the wells now being operated on the public lands in California and in Naval Reserves No. 1 and No. 2. This royalty oil is at present devoted to the payment of the cost of construction of a naval base at Pearl Harbor. If a contract could be made for it according to the terms of which this royalty oil could be acquired for a period of ten years after the completion of the Pearl Harbor contract, or including the period during which the Pearl Harbor contract is being carried on, it would become a valuable adjunct to the above new enterprise, not sufficient, however, to justify the

[1] *Hearings, op. cit.*, p. 1178.

investment of the substantial sums which the enterprise necessitates.

The other assurance which would be required in order to make it possible for the enterprise *to be of advantage to the Government* [1] is the assurance that certain designated lands situated in Reserve No. 1 should when leased be leased to the company establishing such an enterprise, the development of said lands to be done when and as rapidly as required by the Government to protect its lands from depletion by drilling on adjoining territory.

In order that Mr. Doheny's proposition that the Government subsidize him in the expansion of his business activities might appear more attractive, he further proposed: (1) to transport the Government royalty oil to San Francisco without charge, the exchange to be made at that point at the prevailing San Francisco price; (2) to give the Government free storage for 1,000,000 barrels of fuel oil adjacent to the refinery at tidewater and to bunker Government ships at the docks of the new enterprise without profit; (3) to give the Navy the privilege of purchasing any additional fuel oil it might require above the amount which it would be entitled to in exchange for royalty crude at 10 per cent less than the market price at tidewater; (4) to sell to the Navy such manufactured oil products as it might need (gasoline, kerosene, lubricating oils, greases, etc.) at 10 per cent below the market prices.

Mr. Doheny made this proposal to the former Secretary of the Interior in August, 1922.[2] While the proposal was under consideration, Mr. Doheny presented early in November a second memorandum embodying as an added inducement a suggestion that, should his previous proposal be granted, he would maintain for a period of fifteen years 3,000,000 barrels of fuel oil in storage at the disposal of the Navy at various Atlantic and Gulf posts.

The Secretary of the Interior apparently viewed these proposals favorably, but in disposing of the Navy reserves,

[1] Italics mine.

[2] It was in the previous November that Mr. Doheny had made his now famous $100,000 loan to Mr. Fall.

he had adopted the policy of receiving the royalty in kind, to be exchanged for fuel oil. To extend the contract of April 22 for a period of ten years and at the same time to throw open to exploitation additional areas would necessitate a larger programme of storage construction. Therefore the Secretary of the Interior after consultation with the Secretary of the Navy requested that the Pan-American Petroleum Company modify the existing contract to provide for the construction, including the filling, of new storage to aggregate probably $15,000,000 in cost.

With these modifications the proposals of Mr. Doheny were accepted and on December 11 he was granted a lease to all portions of Reserve No. 1 not previously disposed of. According to the terms of the lease, the lessor was to receive a royalty of all oil produced ranging from 12½ per cent to 30 per cent, graduated according to the daily output of the well. The lessee agreed to 'proceed with due diligence' to develop the areas 'provided that the lessee shall not be required to operate . . . more than ten strings of tools at any one time.'

In view of the nature and avowed purpose of Mr. Doheny's proposal of August, this 'due diligence' clause is important. Mr. Doheny had proposed to remedy the demoralized condition of the market resulting from the temporary overproduction of crude petroleum by the construction of additional storage facilities and the operation of a large refinery. That he might carry out this task on the most advantageous business terms possible, he proposed that additional areas in Reserve No. 1 be leased to him. His proposal was granted with the understanding that developments be started immediately and thereby it was made probable that additional supplies of crude petroleum would be thrown on an already demoralized market.

Such briefly are the steps which marked the passing of Reserve No. 1. It will be recalled that at the October, 1921, conference to which reference has already been made, the Bureau of Mines recommended that further data be secured

before taking action as to Reserve No. 3. In September, prior to this conference, a report on the subject of drainage of Teapot Dome had been made to the Secretary by C. H. Weggeman, formerly of the United States Geological Survey but at that time in the employment of a private company, and by F. B. Tough, supervisor of oil and gas operations in the Rocky Mountain fields. On November 30 a report was submitted by K. C. Heald, of the United States Geological Survey, and on February 18, 1922, a report was submitted by A. W. Ambrose of the Bureau of Mines. On about January 1, 1922, Mr. H. F. Sinclair visited Secretary Fall at his ranch at Three Rivers, New Mexico. During this visit the subject of the leasing of Teapot Dome was discussed, although it is not known that any definite understanding was reached. On February 3, Mr. Sinclair submitted to Secretary Fall a memorandum which contained an outline of the terms on which he was willing to receive a contract for the development of petroleum Reserve No. 3. In submitting his terms Mr. Sinclair wrote as follows: [1]

> Being experienced in the production of oil and its manufacture into various by-products, and in its transportation and marketing, my attention has been called to what is known as the Teapot Dome in the State of Wyoming, this area having been reserved by the President for use by the Navy. I now address you on this subject as I understand that it has been found necessary by the Department to make some contract with reference to Naval Reserve No. 2 in California, for the reason that said Reserve was being drained.
>
> This condition, in my opinion, exists in Teapot Dome in the Wyoming field; therefore I submit for your consideration, as merely tentative, the following basis upon which I would agree to undertake the development of this Reserve No. 3.

After setting forth the tentative terms of a proposed contract, Mr. Sinclair closes his memorandum with the following injunction:

> In conclusion, I respectfully suggest that it will be vastly more valuable to the Navy Department to have its oil in secure steel

[1] Senate Document 210, Exhibit M, pp. 41–43.

storage, which does not leak, and which is above ground, and which will be located by the Navy at such points as it may direct, and therefore always instantly available, than to have the oil underground where it is subject to being drained, and perhaps totally lost to the Navy, and far remote from where it could be used.

On the basis of available data regarding drainage, the Secretary of the Interior seems to have come to the same conclusion that Mr. Sinclair had previously arrived at, and on April 7, 1922,[1] the whole of Naval Reserve No. 3 was leased without competitive bidding to Mr. Sinclair on substantially the terms outlined in his proposal. The lease provided, in effect, for the immediate exploitation of the Reserve, the wells to be drilled on a graduated royalty basis varying from 12½ per cent to 50 per cent depending on the output and character of the oil. The Government agreed to sell to the lessee all the royalty oil and to receive therefor to its credit oil certificates which might subsequently be used (1) in exchange for fuel oil of a specified grade, (2) as a credit for the construction of steel-tank storage for the use of the United States Navy to be erected at points designated by the Department of the Interior upon recommendation of the Department of the Navy, (3) in exchange for gasoline, kerosene, lubricating oils or other petroleum products, (4) for redemption in cash. The lessee further agreed that if on the completion of twenty test wells, the lease yielded an average daily production of 20,000 barrels for a period of sixty days, he would begin the 'construction of and continue with reasonable diligence to completion a pipe line of not less than twenty-five thousand (25,000) barrels daily capacity, extending from the lands'[2] to a point connecting with either the Prairie Company's pipe line or the Sinclair Company's pipe line extending from the Mid-Continent field to Chicago, Illinois.

Such in brief were the main provisions of the contract

[1] It was on March 16, 1922, that Mr. Sinclair had presented Mr. Fall with some fancy stock for his New Mexico ranch.

[2] *Hearings, op. cit.*, p. 9.

whereby the last of the naval petroleum reserves was opened for immediate exploitation.

By way of review it will be recalled that until May 31, 1921, the naval petroleum reserves were administered by the Navy Department with such assistance as was required from the Department of the Interior and the Department of Justice. In carrying out its established policy of conservation the Navy Department had maintained a petroleum office in California and an office in the Navy Department in which information was assembled and the efforts of the various officials of the Government having to do with the reserves were coördinated. It would seem that the naval officers in their association with geologists, petroleum technologists, and practical oil men were qualified to advise the department in the administration of the reserves.

For protection against unavoidable drainage in Reserves No. 1 and No. 2 a leasing programme had been launched by the Navy Department. This programme proposed a gradual exploitation of parts of the reserves which seemed in greatest danger of drainage. Such in brief were the conditions when the reserves were turned over to the Department of the Interior for 'conservation, development, and operation.' Within the short time that these properties have been administered by the Department of the Interior, there has been put into effect a radical change of policy — from conservation to exploitation, and within a year the whole of Reserve No. 3 had been leased, practically all productive areas in Reserve No. 2 had been leased to companies previously operating within the areas, and a contract had been entered into regarding Reserve No. 1 which led within a short while to its being opened to exploitation.

The defenders of the leasing programme, executed under the guidance of the Secretary of the Interior, have attempted to justify it on the twofold ground of necessity and expediency. The leasing programme was rendered imperative, we are told, because of the drainage by pri-

vately operated wells within or adjacent to the reserves. It was likewise expedient because under the terms of the lease contracts, provision was made for the construction of storage facilities at strategic points, to be filled with fuel oil for the use and benefit of our Navy. The programme has been further defended on the ground that the construction of a pipe line to the Wyoming oil fields under the provisions of the Teapot Dome contract would result in the breakdown of monopoly and the establishment of competitive price conditions within that area to the benefit of the United States Government in its sale of royalty oil. We shall not attempt a detailed and comprehensive discussion of the merits of these various arguments. The defense of the programme on the grounds that it provided necessary storage facilities for the use of the Navy, and that it would establish competitive conditions in the Rocky Mountain oil fields seems entirely irrelevant. If additional storage facilities were needed to meet the immediate or future needs of the Navy, they might well have been constructed under appropriations provided for that purpose from the national income rather than at the expense of the oil secured from the naval reserves. It is interesting to note that of the estimated 25,000,000 barrels of oil within the Teapot Dome reserve, under the terms of the contract with Mr. Sinclair, the Government will receive ultimately approximately 2,000,000 barrels of fuel oil in storage.[1] The balance will go to the holders of the lease and in payment of the storage facilities. While the Government's share in the California reserves will no doubt total a far larger amount than this, there, too, the bulk of the oil will go to the holders of the lease and in payment for the construction of storage facilities. In view of the rapid depletion of our domestic petroleum resources, and the purposes for which these reserves

[1] Approximately two thirds of the Government royalty oil will be required in payment of the storage facilities. The above calculation is on the assumption that the production from the lease will be enough to entitle the Government to a 20 per cent royalty. Until the close of 1923 the royalty had averaged only about 16⅔ per cent.

were created, exploitation under such terms at any time would seem entirely unwarranted.

The defense of the programme on the grounds that the construction of a pipe line to the Wyoming field will work toward the establishment of competitive conditions in the sale and production of petroleum therein is entirely beside the point. The responsibility for the establishment of competitive conditions in the sale of royalty oil or other oil does not rest with the Department of the Interior. If monopolistic conditions in the oil industry in the Rocky Mountain territory prevented the Government (and incidentally the industry at large) from receiving a fair competitive price for its crude petroleum in contravention of the Sherman Anti-Trust Act, then it would seem to have been the function of the Department of Justice to institute proceedings for the remedy of such a condition. It was not intended, nor does it seem desirable, that competitive conditions be established in the purchase of Government royalty oil at the expense of our petroleum resources. The price is too great. Furthermore, it seems apparent that this pipe line would have been constructed regardless of the Teapot Dome lease. Mr. R. W. Stewart, chairman of the Board of Directors of the Standard Oil Company of Indiana (which company owns a 50 per cent interest in the Sinclair pipe line) testified before the sub-committee of the Senate Committee on Manufactures that quite aside from the exploitation of Teapot Dome, a pipe line into the Wyoming field was a justifiable undertaking and that a programme of construction was already being contemplated.[1] As a matter of fact, the production from Teapot Dome has never been sufficiently great to require the construction of a pipe line under the terms of the leasing contract; yet the construction of the pipe line has been pushed to completion.

The defense of the leasing programme on the grounds of necessity is entirely pertinent. If these reserves were being

[1] *Hearings before the Senate Committee on Manufactures, op. cit.*, p. 797.

drained of gas or oil by wells on or adjacent to them, then obviously it was the duty of our Government to take steps to remedy the situation. As has been previously pointed out, it seems clear that this situation existed in the California reserves. Whether or not there was any danger of substantial loss by drainage of the Teapot Dome Reserve is a moot question on technical grounds. The argument of the Secretary of the Interior in defense of his lease of Teapot Dome rests almost entirely on opinions as to the possible or probable drainage of this reserve expressed by Mr. C. H. Weggeman, formerly of the United States Geological Survey; Mr. Tough, formerly chief oil and gas supervisor of the Bureau of Mines; Mr. Ambrose, chief petroleum technologist of the Bureau of Mines; and Mr. Heald, of the United States Geological Survey. Despite the Secretary's reliance upon the authority of these gentlemen in defense of his programme, it is difficult to find in the reports of any of these men convincing evidence of the probability of an immediate and serious loss by drainage of Teapot Dome. All four seem agreed that the northern portion of the reserve, which is separated from the Teapot Dome proper by a series of faults, is subject to drainage by wells adjacent to the northern boundary of the reserve. It was only of this northern portion, however, that they seemed willing to recommend unqualifiedly a programme of leasing, and while Mr. Heald of the Geological Survey stated that portions of the reserve north of the fault would presumably but not certainly ultimately be drained by wells drilled outside of the reserve, he maintained that at the rate of production at the time of his report a year or more must elapse before any part of the reserve would be appreciably damaged, and recommended strongly against any leasing south of the fault. Mr. Frederick Clapp, expert geologist employed by the Senate Committee on Public Lands and Surveys to investigate the question of loss by drainage in Teapot Dome, states unequivocally that at least 30 per cent of the oil-bearing areas of the reserve

remained 'unsusceptible of drainage or reduction of recoverable oil in any commercial degree; and this limitation to serious drainage or reduction . . . was approximately ascertainable before the execution of the lease.[1] On the other hand, Mr. James O. Lewis, who also made a report for the Senate Committee on the problem of drainage in Teapot Dome, is of the opinion that the whole area would ultimately be subject to drainage from wells outside the lease.[2] It seems to be the consensus of opinion among those qualified to speak that a portion of the Teapot Dome Reserve was susceptible to drainage by wells drilled on the Salt Creek structure to the north. This fact, however, would scarcely seem to warrant the leasing of the reserve. Dr. Mendenhall, chief geologist of the United States Geological Survey, testified that the 'reserve was created to include the Teapot structures, but that its boundaries were necessarily drawn somewhat beyond what we believed to be the limits of the structures, in order that there might be a protective strip about them. Therefore the northern part of Reserve No. 3 is somewhat north of the Teapot structures, it is on the southern slope of the Salt Creek structure. It is inevitable that drilling along the northern boundary of the reserve will draw some oil from the reserve, but it is my personal belief that practically no oil would be drawn from the Teapot structure which is within the reserve and covers a less area than the reserve itself.' [3]

In passing judgment upon the wisdom of our federal policy in the disposition of our petroleum resources, it is important to note, that the wells which were an actual or potential source of danger to the northern portions of Reserve No. 3, were wells drilled on Government lands in the Salt Creek structure to the north, leased to private operators under the provisions of the leasing act of February, 1920. In throwing open to private exploitation Government lands outside of the naval reserves, we thereby created a menace,

[1] *Hearings, op. cit.*, part 1, p. 112. [2] *Ibid.*, p. 96.
[3] *Ibid.*, part 3, p. 699.

potential or real, to their integrity. Responsibility for this, of course, rests largely upon our congressmen. The menace was made the occasion for the opening of the entire area to immediate private exploitation.

While it seems that the leasing of Reserve No. 3 cannot be defended on the ground that it was subject to serious and immediate loss by drainage, yet it must be recognized that its ultimate oil recovery would probably have been somewhat diminished by the loss of gas pressure and drainage from the wells on Government property to the north. Reserve No. 1 was menaced from within to a greater extent, while Reserve No. 2, by reason of the great number of private claims therein and the degree to which exploitation had already progressed, was no longer in any real sense a reserve. These facts seem to have been quite generally recognized even by those most interested in the Navy's programme of conservation. However, they scarcely afford an adequate defense for the irregular manner in which the Interior Department's leasing programme was so expeditiously carried through. But it must be recognized that even if the Secretary of the Interior had been as keenly alert in guarding the public welfare as he is charged with having been in looking after his own interests, it is extremely unlikely that an endeavor along conventional lines to preserve the petroleum underground would have proved successful. The fundamental difficulty with the programme of conservation which the Navy Department had clung to so tenaciously was its incompatibility with the existing system of oil production. The well-meaning plans of our conservationists, reinforced though they were by executive order and Government decree, would eventually have proved powerless to protect and preserve intact the underground store of petroleum against the resistless and overwhelmingly expulsive force of compressed gas once the reserve had been tapped.[1]

[1] This statement does not apply to the Teapot structure, as distinct from the Teapot Reserve, the reserve having been made larger than the structure for protective purposes.

As a programme of conservation, defense can scarcely be made of the disposition of the reserves for immediate exploitation. This procedure defeats at once and for all time the purpose for which the reserves were created; but the programme, providing for the gradual leasing of strips adjacent to privately operated wells which had already been inaugurated by the Department of the Navy, would likewise have eventually frustrated in large measure the aims for which the reserves were created. A genuine solution of the problem necessitated a more radical programme than even the Navy Department seems willing to have suggested. The unregulated, property-owning basis for exploiting a migratory mineral certainly endangered, and seemed likely to render futile, the effort to ensure for the future a supply of petroleum underground and secure within the naval reserves. But the public interest in these reserves was paramount and private rights to property might well have submitted to modification in the public interest. The situation, were there no other way out, certainly justified the exercise of the right of eminent domain.

CHAPTER XV

IS THERE A WAY OUT?

THE premature development of the federal petroleum lands has been quite in keeping with the generally wasteful manner in which the resource has been exploited. It has its explanation in the same fundamental causes. The basic difficulty has been a failure to take account of the natural conditions under which oil is found. The unregulated property-owning basis of oil exploitation has rendered difficult, if not impossible, the application of available technique whereby order might have emerged from a condition of chaos. The inevitable result of unrestricted competition in the production of crude petroleum has been waste — waste on a scale sufficiently grand to excite the admiration of the most profligate.

The people of the United States, however, have not as yet been greatly disturbed about this waste, and such direct interference or control as our Federal Government has seen fit to exercise through the anti-trust laws has tended to encourage rather than check wasteful methods of exploitation. Nevertheless, our federal policy has not been entirely devoid of constructive and far-sighted endeavor. Our Government has begun to concern itself in a constructive manner with the development of our mineral resources. A study of future federal policy toward the oil industry must begin with a consideration of what has already been accomplished in reference to this limited natural resource.

The Federal Government to-day makes direct contact with the oil industry through two organizations designed to promote greater efficiency in the production and utilization of our mineral resources — the Bureau of Mines and the United States Geological Survey.

The United States Geological Survey had its inception

in the employment of Dr. F. V. Hayden in 1867 under the direction of the General Land Office. An appropriation of $5000 had been made by Congress and Dr. Hayden began work as the first Government geologist on a survey in Nebraska. The following year the appropriation was renewed and field work was extended into Wyoming. From year to year thereafter Congress increased the amount of its appropriations for geological work and numerous surveys were conducted in various sections of the country. In 1878 the various surveys were consolidated under the United States Geological Survey and Clarence King was appointed as director in 1879. The United States Geological Survey, through its comprehensive and extended studies of geology, has since made a notable contribution to the oil industry. Although it is difficult to appraise exactly the importance of geology in the discovery and development of petroleum fields, it is generally conceded to-day that the science of geology has multiplied many times the chance of striking oil, and it is definitely known that wherever it is used in production operations it has greatly increased the productivity of fields by affording a more complete control of the natural extractive forces. Having recognized the services which geology may render both in finding and developing oil fields, almost every company of importance has for a number of years had its staff of geologists. The judgment of these men has largely guided oil prospecting and development work within recent years. It is important to note that the points of departure for the work done by these company geologists have been the studies of a general or regional nature conducted in large part by the United States Geological Survey.[1] These studies have been of both an extensive and detailed character, and when completed they have furnished the tools with which geologists employed by private companies have worked. An important recent project of this nature has been the tracing of sedi-

[1] The various State surveys have likewise made notable contributions in this field.

mentary formations (Cambrian to Tertiary inclusive) and their correlation through Eastern Colorado and Wyoming. This study has been carried on through many areas where oil is not known to exist and where it will probably never be found; but the study is considered an essential part of the programme for the development of Wyoming's oil resources. The Survey is constantly on the search for possible new oil fields. Areas in which no drilling has been attempted or where drilling has been unsuccessful are studied in detail with a view to discovering their possibilities. In this regard it is interesting to note that more than two thirds of the fields of Wyoming are on anticlines discovered by Survey geologists and called to the attention of the public through publications of the Survey. The famous Mexia field of Texas, opened in 1921, was described in two Government publications before that date. The Bellevue field of Louisiana is on an anticline discovered by Survey geologists in 1907. The recent opening of the so-called Wheeler Ridge field of California is not altogether a discovery for it is on an anticline which was described as promising by a geologist of the Survey as early as 1912.

The Survey has, likewise, conducted detailed studies of producing fields which have led to the extension of oil fields and in some instances to the discovery of sands which had been overlooked in early exploration. While these studies have been of great value in the development of particular areas, they have served a broader purpose since they have led to the discovery of principles or habits of petroleum occurrence that may apply over a large area and which are of great value when new fields in the general region are found. In these and in numerous other ways the Survey has directed its efforts toward a scientific and orderly development of our petroleum resources.

The Bureau of Mines has also in a definite and constructive fashion assisted in the development of the American oil industry. The Survey's efforts in connection with petroleum have been directed largely toward the discovery

of new oil regions and the study of conditions under which petroleum occurs. The Bureau of Mines has been more concerned with the problem of assisting the economical and efficient development of oil fields. The Bureau of Mines was established by act of Congress, in 1910, for the purpose of conducting scientific and technological investigations concerning mining in its various branches, and the production, utilization, and conservation of petroleum and its products. The Bureau's organization for furthering the petroleum industry is at present divided into four branches or sections: production technology, engineering technology, chemical technology, and oil-shale technology. Our chief interest centers in the work performed by the sections of production technology and engineering technology.

The section of production technology devotes its attention to the general problem of efficiency in oil production. Its work involves the collection of well logs, casing records, production records, sand depths, and other specific data descriptive of the underground geological and physical conditions. The objects of its studies are to protect oil sands against waste of oil or gas and to ensure thereby a maximum recovery of oil from developing areas. Field offices of the Bureau have been established in or near the more important producing sections, and several engineers of the Bureau devote their entire time to the study of production problems in Wyoming, California, Oklahoma, and Texas. The efforts of the Bureau and its accomplishments in the Mexia, Texas, field have already been briefly described.[1] These are typical of its work in other fields. Cooperative work which was carried on with the Indian Office under an annual appropriation of only $17,500, resulted in increasing the production of one group of oil wells in the Cushing field by more than three thousand barrels per day. This result was accomplished through the proper control of underground waters.[2] The increased oil production for the

[1] See Chapter X, pp. 199 *et seq.*

[2] Cottrell, F. G., formerly director of the Bureau of Mines, *Relations*

first year succeeding the repairs of the wells had a pecuniary value of more than $2,000,000.

Many operators have come to appreciate the value of the Bureau's endeavors and in some instances operators have coöperated actively with it in carrying its work forward. In 1919 the Bureau issued a report on production operations in the Salt Creek field of Wyoming, describing the nature of wastes from underground sources in this field. Following this report a conference was held by the Director of the Bureau of Mines with representatives of three large companies operating in this section — the Midwest Refining Company, the Ohio Oil Company, and the Continental Oil Company. As a result of this conference, these companies together subscribed $30,000 to be expended in one year under the direction of the Bureau of Mines to 'make investigations for the purpose of determining the best method for the conservation of petroleum and natural gas, and for the protection of oil wells and oil or gas-bearing strata against damage and waste from infiltrating water and other causes.' [1] The money is said to have been subscribed with the understanding that the knowledge and experience gained was for the benefit of the industry at large, regardless of who had or had not contributed to the financial support of the work.[2] To carry out the work the 'United States Bureau of Mines (Rocky Mountain Petroleum Association)' was formed. At the end of the first year the contributing parties signed an agreement for the continuance of the work for another year. In March, 1921, Congress appropriated funds to the Bureau of Mines for the supervision of drilling and production of oil and gas produced on Government lands. The Bureau's men were thereafter transferred to this work, and the Rocky Mountain Petro-

of the Bureau of Mines to the Oil Industry, Reports of Investigations, Serial No. 2166, p. 2.

[1] Quoted from the agreement executed by the Bureau and the companies, in Tough, F. B., *Report of Operations, Rocky Mountain Petroleum Association*, p. 5.

[2] *Idem.*

leum Association was disbanded. Although its life was short, the Association seems to have rendered a valuable service both of a specific and a general sort. The most important result accomplished seems to have been 'a general and decided improvement in operating methods throughout the Rocky Mountain district.' [1] Specifically the Association is said to have saved or earned for the industry, i.e., for the individual operators concerned, over $307,000 on four tasks alone. In addition numerous less important services were rendered, ranging from free office advice to actual field supervision.

Through the section of engineering technology, the Bureau of Mines has made valuable recommendations for the transportation and storage of oil. Recently investigations conducted by it have disclosed that in many cases 20 per cent of the volume of the gasoline content of crude petroleum is being wasted by evaporation before it reaches the refinery.[2] The investigations indicated that probably at least one half this loss could be saved. This section has carried on detailed investigations to ascertain the causes of the fires which occur so frequently in oil-field regions. The importance of work of this nature may be judged by the fact that during the ten-year period from January, 1908, to January, 1918, approximately 12,750,000 barrels of oil and 5,024,506,000 cubic feet of natural gas were destroyed by fires of an accidental origin in the United States, entailing a total loss of more than $25,000,000. The Bureau's investigations revealed that most of the more important fires resulted from carelessness or from improper storage and transportation of petroleum. The Bureau has been able to suggest means for successfully combating the most disastrous fires and has entirely eliminated hundreds of lesser fires. Through the adoption of its recommendations many thousands of dollars have been saved to the industry and enormous quantities of oil and gas conserved for use.

[1] Tough, *op. cit.*, p. 5.

[2] See Chapter XI, p. 236.

Thus, in numerous ways the United States Geological Survey and the Bureau of Mines have endeavored to guard the public interests in the development and utilization of our petroleum resources. Both bureaus have been energetic in their endeavors to assure the public a supply of petroleum adequate to meet for some time the vital needs of modern industry. Although their efforts have been scientific, the success which they have thus far achieved has been slight compared with the wastes which still occur. The work of the Survey has been in the right direction, but it has not gone far enough. The Survey has rendered notable service in making available for exploitation large areas of land, rich in their underground store of petroleum, but it has had no control over the methods by which the underground supply of petroleum has been recovered. The exploitation of the resource has been a private matter, dominated by the motive of private gain. The results of this policy have been set forth in detail in the foregoing analysis. The lure of great gains coupled with the migratory nature of petroleum have driven its production relentlessly and insistently onward with little regard to immediate or future needs. They have likewise rendered the industry peculiarly unresponsive to the price factor in periods of overproduction or of slack demand. Uncontrolled and unregulated production has involved a large element of waste, but it has also resulted in a flood of petroleum over the land. New and uneconomical uses have been found for its surplus products, and these new demands once established have further accelerated the rate of exhaustion of our resource.

Although the efforts of the Bureau of Mines have attained a modicum of success, its work has been handicapped at every point by the haphazard methods of competitive, private exploitation. It should be noted that its labors, in so far as its productive activities are concerned, have been almost entirely of a remedial sort. It has been called in or has volunteered its services when local conditions were

rapidly passing beyond the stage of remedy. And on every hand it has been handicapped by the lack of adequate data with which to diagnose the source of trouble. Production activities have proceeded apace. The Bureau's staff has been small, and only where and when conditions have been extremely bad, has it been able to render its assistance. Its services, freely given, have eliminated losses and have increased profits for individual operators in numerous instances. Likewise, they have no doubt improved in a small measure the general efficiency and economy of oil production, but in proportion to the magnitude of the wastes involved, the success attained has been negligible.

The fundamental shortcoming of our federal policy, as evidenced in the work of the Bureau of Mines, is that it attacks the problem at the wrong point. We endeavor to apply a palliative without striking at the root of the evils. Where competitive practices have gotten the individual operators into trouble, the Bureau renders its assistance, but the industry at large remains a victim of the uncontrolled competitive methods of private exploitation.

But as we turn from the past and look toward the future, the question recurs: Is there a way out? The first step in a remedy, of course, presupposes an understanding of the basic principles involved. These problems we have discussed in the foregoing pages. The facts of the situation seem convincing. Competition in the petroleum industry works at cross-purposes with the economical exploitation and utilization of petroleum. We have emphasized this fundamental fact throughout the entire discussion. The fault is largely a matter of maladjustment between the physical facts of oil geology and the ownership basis of oil production. There is no changing the former. A solution seems to demand some modification of the latter. As with coal, so with oil, 'the public interest . . . raises fundamental questions of the relation of this industry to the nation and of the degree to which private rights must yield to public welfare.'

It has not been the purpose of this study to present a definite and detailed programme of remedy but rather to set forth in a clear light the fundamental shortcomings of existing methods. But with an intimate knowledge of the chaotic condition which exists in the oil industry, rendered more complicated by the intricate nature of overlapping property rights and interests, we have the temerity to suggest that, waiving difficulties of a constitutional nature, the following constructive steps might lead toward a way out.

As a preliminary measure the scope of the authority of the commission recently appointed by President Coolidge to study the problem of the conservation of petroleum with particular reference to a naval oil supply should be broadened to include a survey of the problem of petroleum conservation in its more comprehensive aspects and to make recommendations for a specific programme pertaining thereto.[1] Secondly, the Leasing Act of 1920 so far as it relates to petroleum and natural gas should be amended. The public lands, which have been thrown open to private exploitation during a period of heavy overproduction, might more properly have been regarded as in the nature of an insurance reserve to relieve a possible future shortage when commercial supplies are on the wane. Exploitation, whenever undertaken and whether by public or private agency, should have as its basis of operation, the underlying geologic unit rather than the surface property tract. Thirdly, a comprehensive system of federal regulation and control of petroleum production should be instituted. We already have the agencies around which the necessary administrative machinery might be constructed. The problem

[1] Since the above was written the President has appointed the Federal Oil Conservation Board composed of the Secretary of the Interior, the Secretary of the Navy, the Secretary of War, and the Secretary of Commerce. At a meeting of the Board on January 7, 1925, a sub-committee consisting of departmental representatives was organized to make a comprehensive study of the problem of petroleum conservation and to attempt to formulate, with the advice of the industry, a conservation programme.

of the economical production and utilization of petroleum has a twofold though interrelated aspect — control of the rate of production and the application of a scientific technique in the recovery process.

Already the United States Geological Survey and the Bureau of Mines have made some progress in the direction of a solution of this twofold problem. Their work has been advisory in character and their accomplishments have necessarily been limited by their lack of authority. The United States Geological Survey in its general work of petroleum finding and its more specific work in the collection of data on current production and stocks on hand has furnished a point of departure for the control of output. Effective control of production would involve the regulation of the broader features of developmental work connected with the opening of new pools and the extension of old. It would also necessitate control over the more detailed matters of well locations, spacings, etc. The Bureau of Mines has likewise made some progress in the application of scientific technique in the recovery process. Its accomplishments in this regard have already been briefly described. With authority centralized under these two organizations, effective administrative machinery might be constructed for an adequate control of production operations. Waiving the question of jurisdiction, existing State agencies might be utilized, and their efforts centralized and coördinated under the federal bureau. The central agency would serve as a clearing-house of technological information regarding underground geological conditions; and the application of technique by private operators would be under the general guidance of the central bureau. Such a programme would obviously necessitate a modification of property rights in the public interest.[1]

[1] The above discussion is intended as merely suggestive. It is believed, however, that conditions might be greatly remedied through an extension of authority of the federal bureaus along the lines suggested.

Controlled production paves the way for a more economical utilization of petroleum products. Overproduction has been the prime cause of incomplete refining practices. It has delayed the application of technique available for complete extraction of the more permanent petroleum values. With production somewhat retarded, the price factor would necessitate a wider use of more economical and efficient refining methods. Controlled production, together with a revision of our patent law designed to encourage a more widespread use of the cracking process, might prove an adequate solution to the problem of efficiency in the use of petroleum products.

In so far as the problem of petroleum transportation is concerned, the naturally monopolistic nature of the industry should be recognized and should be made the point of departure for an intelligent policy of public control.

The wastes encountered in the marketing of petroleum products are not peculiar to the petroleum industry. Excessive duplication of equipment seems to be a necessary concomitant of competitive enterprise. And it may well be that the wayfaring man secures a greater net benefit from the competitive, profit-seeking production and distribution of economic goods in general than he could hope to secure from any system designed directly to serve him.

Before concluding we wish to suggest that the competitive private exploitation of petroleum, with all its shortcomings, has perhaps not been without its compensations. It has made for a tremendously rapid development of the resource, and that, in turn, has permitted a correspondingly rapid development in the use of petroleum-consuming devices. Private exploitation of petroleum may account in large part for the current widespread use of the motor car, and the motor car no doubt has brought with it its train of worth-while social consequences. It may well be that as the resource becomes exhausted, human ingenuity will devise adequate substitutes, in which case, our prodigal waste of petroleum resources may in the light of history be

considered to have made for more rapid and permanent social progress. History, however, is not without its illustrations of predatory exploitation of natural resources followed by periods of economic pressure. By taking thought we may be able to avoid a recurrence or mitigate the severity of such periods. The problem of economic welfare becomes more pressing as population increases and natural resources become exhausted. In so far as the petroleum situation is concerned, it should be recalled that it has been estimated that the reserves of this country have already been reduced by possibly one half and the rate of exhaustion has been greatly accelerated within the past decade. The material circumstances of life change with startling rapidity. On the other hand, social groups cling with tenacity to the accustomed ways of doing and thinking, and the petroleum situation seems not unlikely to get entirely out of hand before any constructive programme will have been instituted.

But the larger problem of effective control over natural resources for human and social ends will remain, perhaps intensified. It may well be that men are not 'capable of directing their own industrial destinies on the single incentive of supplying their own bread and beauty.' But whether or no, the case of petroleum repeats the 'challenge of waste.'

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